engraving ca. 1900

# *Evolution's Second Chance*

## Forward-thinking paleoecologists advocate "jump-starting" diminishing biodiversity

**by David A. Burney, David W. Steadman, and Paul S. Martin**

PALEOECOLOGISTS ARE PEOPLE who think big when it comes to time. In particular, those who study the late prehistoric fossil record are predisposed to long-range concepts that bridge the gap between deep time and the present. Thinking on long time scales that can even be extrapolated into the future comes fairly naturally for some paleoecologists, it seems—including those participating in an unusual symposium held last year at the University of Hawaii-Hilo, during the annual meeting of the Society for Conservation Biology (SCB).

Entitled "Island Paleoecology: Draining the Past to Irrigate the Future," the symposium featured speakers whose research into the past points to some possible future directions in conservation biology, particularly in the beleaguered island ecosystems of the world. Like other symposia offered at the SCB meeting that focused on the problems of island ecosystems, much was said regarding the deep damage inflicted by biological invasions and other human-mediated assaults on insular systems.

Reconstructions of ecological changes of recent millennia in the Hawaiian Islands, the South Pacific, and Madagascar, for instance, disclose lands totally transformed since human arrival. Each of the world's islands can be viewed as a sort of experimental treatment in human ecology, showing with hundreds of replicates that people, even with rudimentary technology, are capable of crushing biodiversity through resource overexploitation in its varied forms and translocation of exotic species to places they would never reach on their own. In this rather sad way, paleoecology provides conservation biologists with powerful parables.

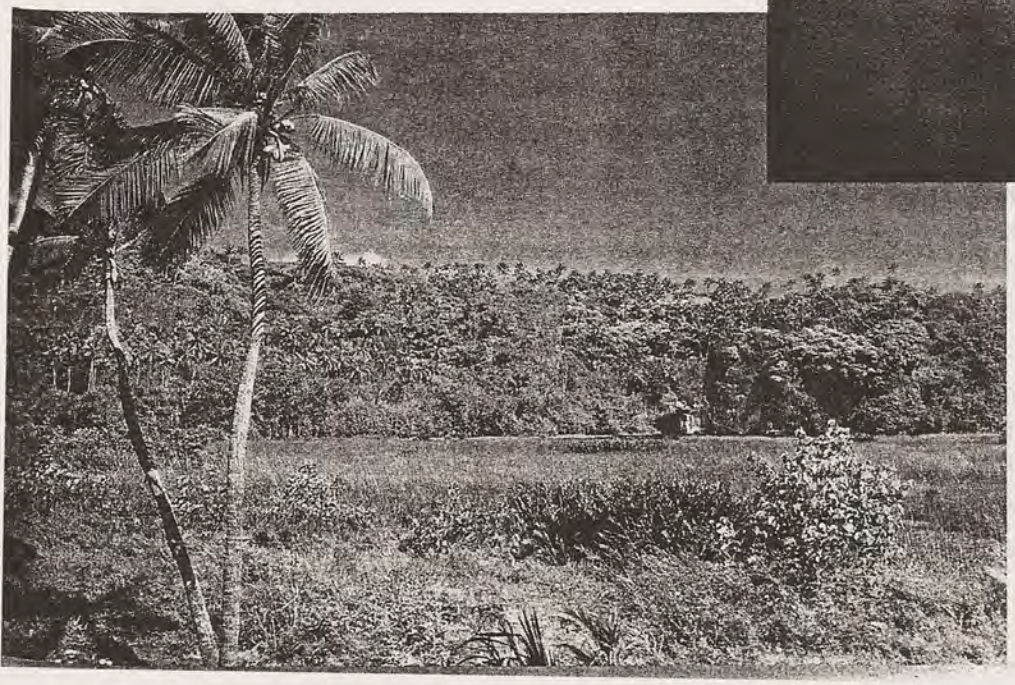
With these same data, however, paleoecology also can point to positive directions for the future. Conservation biology has often been criticized for its siege mentality, as the field is of necessity a crisis discipline, in which rearguard actions and damage control are standard operating procedures. Proactive proposals are relatively rare and likely to be viewed with suspicion. Grand schemes, after all, are more typical of developers. Nevertheless, it was clear in the open discussion following the six symposium speakers that the conservation community is cautiously receptive to advice—even fairly rad-

ical-sounding suggestions—from the paleoecological community. Speakers advocated giving species with little apparent chance of survival in their remaining diminished habitat a second chance by restarting populations well outside their present range, but in places roughly corresponding to the greater range that the late prehistoric fossil record shows they occupied when humans first arrived.

The Laysan duck (*Anas laysanensis*) is an often-mentioned example. Less than 500 of these terrestrial, insect-feeding birds lead a precarious existence on tiny (4.1 square kilometers), low (12 meters elevation), uninhabited Laysan Island in the Northwestern Hawaiian Islands chain. The entire wild population could succumb to a single hurricane or tsunami of no greater magnitude than several that have struck elsewhere in the mid-Pacific in historic times. Although earlier studies consider the species to be a single-island endemic, abundant fossil evidence tells a very different story: this little duck was widespread throughout the major Hawaiian Islands when the Polynesians arrived about a millennium ago, and was almost certainly extirpated by prehistoric hunters and their introduced commensals. This endangered bird's eggs may soon be in more than one basket. A study by Michele Reynolds is currently examining the feasibility of reintroductions to national wildlife refuge areas in the Hawaiian Islands that are protected from rats, exotic predators, and ungulates.

Some paleoecologists believe that as many as 2,000 species of flightless rails have disappeared from the myriad islands of the South Pacific in a similar way. These birds could be restarted in the evolutionary sense on a host of suitable small, relatively predator-free islands, using the roughly 20 species that have survived, many of which are endangered. The Guam rail (*Gallirallus owstoni*), for instance, thrives in captivity, but was extirpated in the 1980s on Guam by the introduced brown tree snake (*Boiga irregularis*).

The raised limestone island of Aguiguan (7 square kilometers, 157 meters elevation) in the Mariana Islands is uninhabited, surrounded by cliffs, and mostly forested. Unlike many islands in the region, it lacks a wharf, an anchorage, roads, highways, vehicles, cats, dogs, and black rats (*Rattus rattus*). The only non-native mammal is the small Pacific rat (*R. exulans*). Hundreds of bones of an extinct, flightless species of *Gallirallus*, similar to the Guam rail, have been found at Pisonia Rockshelter, an archaeological site on Aguiguan ranging from 1,800 to 500 years old. Also found were bones of *Ducula oceanica*, a large pigeon that survives in parts of Micronesia today but nowhere in the Marianas. Both of these would be likely to reestablish populations on Aguiguan if restocking took place. Brown tree snakes, which have devastated Guam's birdlife in recent decades, now have been found on the adjacent inhabited



The banded rail (*Gallirallus philippensis*), a prime candidate for restocking certain islands to test whether flightlessness can evolve again in a setting free of mammal predators. JAMES STULL

Mangaia, Cook Islands. Although inhabited by people, this island retains enough forest to be considered as a potential site for translocating populations of endangered birds, especially certain pigeons and doves. DAVID STEADMAN

islands of Rota, Tinian, and Saipan. Aguiguan's inaccessibility means that it likely will remain free of snakes.

The Kingdom of Tonga, a Polynesian archipelago of 170 islands, 40 of which are uninhabited, is a world leader among nations pioneering this approach. A megapode, the Niuafo'ou scrubfowl (*Megapodius pritchardii*), is traditionally regarded as endemic to the northern volcanic island of Niuafo'ou. Its bones have been found on six islands scattered over the archipelago, suggesting a virtually archipelago-wide distribution when people arrived 2,800 years ago. Over the last decade, biologists have taken eggs of *M. pritchardii* from Niuafo'ou to the volcanic islands of Late and Fonualei, where adult birds are now common. Success is also reported with the ground-dove *Gallicolumba stairi*.

The translocation program in Tonga has been low-tech and low budget, but has enjoyed full cooperation from the national government, from aviculturalists at the private Tongan Wildlife Centre, and from visiting ornithologists. The bottom line is that the program is working, with current plans for more reintroductions.

Paleoecological research indicates that plant evolution also may benefit from jump-starting. Work by a multidisciplinary team on a spectacularly rich Holocene fossil site in the Maha'ulepu Caves of Kaua'i has shown clearly something that had been suspected about many currently endangered species of plants, invertebrates, and birds in the Hawaiian Islands, and by extension elsewhere. Many taxa that are rare today and restricted to a few high mountains or steep upper valleys have such restricted and often disjunct ranges only as an artifact of human activities. Trees like *Kokia kauaiensis* and *Zanthoxylum* spp., for instance, are today found in a few spots on rugged mountains in the interior. When Polynesians arrived, these trees and many others, including the attractive endemic palms of the genus *Pritchardia,* were growing at sea level on the dry leeward coast of the island, the Maha'ulepu record shows. The lesson from analyses of fossil pollen and seeds should be clear for conservation biologists: many rare species may be barely surviving today in sub-optimal environments (often very steep) that bear little resemblance to their typical habitat at first human contact. The human onslaughts of deforestation, introduced herbivores, and diseases usually do their work most rapidly and thoroughly in coastal lowlands. With the right kinds of protection, many rare plant species could be reintroduced to converted or degraded lowland habitats of Hawaii where none are found today—from hotel grounds and golf courses to abandoned cane and pineapple fields.

Forward-thinking students of the past sound some notes of caution in the midst of this otherwise upbeat vision: much has been lost irreversibly. Most island communities that evolved in the absence of ruminant grazers and browsers, from Hawaii to Madagascar, will never again be entirely free of these foreign influences. Rats, pigs, and introduced predators are grave problems, as are diseases such as avian malaria, which has now eliminated nearly all the endemic Drepanidine honeycreepers (Hawaii's spectacular radiation from a single finch ancestor) below 1,200 meters elevation. Work in New Zealand and elsewhere has shown, however, that significant gains can be made on small islands just by attacking one of these problems through rat eradication programs. The U.S. Fish and Wildlife Service and National Park Service have made great strides in the Hawaiian wildlife refuges and national parks controlling feral goats, pigs, cats, and dogs, with a current focus on rats.

The great public-relations obstacles to these eradication programs need to be addressed by the paleoecological community. Numerous fossil studies demonstrate the correlation between the introduction of rats and the decline of native plants, invertebrates, and birds, in some cases beginning more than a millennium ago with the introduction of the small Pacific rat by colonizing Polynesians. Similarly, the fossil record should dispel once and for all the widespread notion among pig-hunters and pig-lovers of Hawaii and other Pacific islands that pigs are native and therefore no threat to island ecosystems. Instead, there is a hint in some fossil evidence that the small pigs first introduced by prehistoric Polynesians were not very successful feral invaders, and that the wholesale proliferation of "wild" pigs on many tropical islands may have come with the introduction of large European varieties in recent centuries.

Human-induced biological invasions are a fundamental problem in nearly all natural communities, insular and otherwise. One ironic effect of the exotics problem is the fear of any talk of reintroducing species. This reluctance includes species or genera that were present in evolutionarily recent time but are now lacking. Professional guidelines for reintroductions emphasize justification from a historical presence, neglecting the late prehistoric fossil record. The long debate over controlling wild horses and burros in North America (missing from the fauna for eleven millennia but present for millions of years

prior to that) is a good example. Perhaps we lack not the ecological and technical know-how, but the appropriate philosophical underpinnings to evaluate future proposals. The recent fossil record provides appropriate models and justifications.

These and other ideas emerging from students of the past are frightening to some conservationists but healthy for the discipline. The Society for Conservation Biology, the Society for Ecological Restoration, and other science-based conservation organizations must advance the discussion, fostering new opportunities by developing not just the techniques, but the attitude and philosophy necessary to accommodate possible breakthroughs suggested by fossil evidence. This is a powerful idea with global implications for saving species and restoring ecological processes.

Try to imagine an Atlantic Ocean that once again has gray whales and monk seals, Madagascar with giant tortoises, ratites, and hippos—maybe even North America with elephants and lions. The late Quaternary fossil record supports all of these as proposals worth considering, from ecological and evolutionary perspectives. Appropriate candidates for reintroduction are available, despite potential logistical and political obstacles. Each new jump-started population would represent another independent evolutionary track into the future, where there would have been few (if any) otherwise. Of course not every attempt will succeed, but those that did would represent genuine progress, not only in ensuring long-term survival of evolutionary lineages, but also in providing collaborative opportunities for a wide range of scientists to make important discoveries. A multiplicity of data on the individuals translocated, for instance, could provide fascinating baseline information for studies of genotypic, phenotypic, and ecological changes over subsequent decades.

Some critics will suggest that addressing human-mediated losses of biodiversity through bold reintroductions is "playing God." This notion ignores the fact that we have been playing the Devil with other species for millennia, punishing many and condemning some to oblivion, usually inadvertently. Humans have seldom redeemed these lost species through reintroduction—even when it would have been a simple job. Already we have altered forever the course of evolution through a host of human-caused extinctions and exotic introductions, but we have the capability to undo part of the damage by setting some of the derailed evolutionary lineages back on the track. Where the train will go is for Nature to decide. ☾

**David Burney** *is an associate professor in the Department of Biological Sciences at Fordham University in New York. He studies the paleoecology of Hawaii and Madagascar.* **David Steadman** *is a professor at the University of Florida and a curator at the Florida Museum of Natural History in Gainesville. He has studied bird extinctions in many regions, including the South Pacific and West Indies.* **Paul Martin** *first proposed the "Blitzkrieg Hypothesis" to explain the global pattern of late prehistoric extinctions. He is a professor emeritus in the Department of Geosciences at the University of Arizona in Tucson.*

## RECOMMENDED READING AND SOURCES

For background on the extent of prehistoric transformation of islands, see Steadman (1995) for the South Pacific; Burney (1999) for Madagascar; and Burney et al. (2001) for Hawaii. The books edited by Martin and Klein (1984) and MacPhee (1999) draw together many viewpoints and examples from throughout the world on the subject of late prehistoric extinctions. For reviews of the historical background to the current biological invasion crisis and its role in the future of evolution, see Atkinson (1989) and Burney (1996). For recent arguments in favor of megafaunal restoration in North America, see Martin and Burney (1999) and Flannery (2001).

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