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Extinction on Islands: Man as a Catastrophe

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From a paleontological viewpoint, extinction is a pervasive, nearly inescapable natural process, though one that is hardly better understood than such phenomena as speciation. The threat of extinction has been among the primary motivators of the conservation movement, because most historic extinctions have been due to man and are thus regarded as unnatural and preventable.

If we look at historically documented extinctions, we find almost none of exclusively marine organisms. Although there is now great concern for habitats on continents, comparatively few extinctions have been documented in continental areas during the historic period. It is only when we turn to islands that man's negative impact on biotic diversity can be truly appreciated so far. Recognition of man-caused extinctions on islands can be traced back at least as far as the disappearance of the dodo (*Raphus cucullatus*) from Mauritius in the 1680s. Since then, many other species and populations of organisms have been exterminated on islands, as perhaps best exemplified by birds (Greenway 1958).

Because until recently there was no paleontological record for most oceanic islands, it was natural to assume that European man was chiefly responsible for the degradation of insular habitats that has resulted in historically documented extinctions. This, in combination with the "noble savage" fallacy, has led to a gross underestimation of the effects of man on insular biotas. Now, with the paleontological record being expanded to many more islands, we have sufficient data to hint at the true magnitude of the losses.

The most startling data have come from the islands of the Pacific. Bones of the gigantic flightless moas of New Zealand were discovered more than a century ago. Since then, much more of the previous avifauna of New Zealand has been documented from archaeological, swamp, cave, and dune deposits. The chronology of extinction leaves little doubt that the Maoris, through hunting and burning, have had a devastating impact on the biota of New Zealand (Cassels 1984; Trotter and McCullough 1984).

I have calculated the number and percentage of extinctions of resident land birds for New Zealand and the Chatham Islands, excluding species known or likely to have colonized the islands since the arrival of man. My systematic judgments are probably at variance with those of others attempting the same calculations, but the overall results would probably not be much different. I get figures of fifty-two extant resident species of land birds, of which at least nine are endangered. Extinctions in the historic period number twelve, and thirty-two species were exterminated prehistorically. Thus, 46 percent of the original fauna is now extinct and 33 percent of the fauna became extinct prehistorically.

A recently completed study of bird remains from late Holocene cave deposits in New Caledonia (Balouet and Olson 1988) documents the extinction of hawks, megapodes, pigeons, owls, a gallinule, and a snipe, in addition to the peculiar, gigantic, flightless galliform bird (*Sylviornis*). These fossils show that at least 25% of the resident species of nonpasserine birds of New Caledonia were exterminated prehistorically, almost certainly as a result of human disturbance. But the fossil faunas are demonstrably incomplete, and again, there are a number of species that have probably colonized the island since the arrival of man. Taking these factors into account, we have extrapolated extinction at at least 40% for nonpasserine birds. To this may be added the extinctions of a monitor lizard, a very peculiar crocodilian, and the horned turtle (*Meiolania*).

In the Hawaiian Islands, prehistoric man-caused extinctions were truly massive in scale (Olson and James 1982, 1984) and included large flightless geese, flightless ibises, many flightless rails, owls, an eagle, a hawk, a petrel, and many species of small passerines. Bones from archaeological sites, Holocene sand dunes, lava tubes, and sinkholes have so far documented the extinction of 50 species, equaling 51% of the total number of native land birds of the archipelago. This is in addition to the 17 species that became extinct in the historic period, so for the total avifauna yet known, 69% of the species are extinct. For the two islands with representative fossil faunas, prehistoric extinction was 69% on Oahu and 71% on Maui, where only 10 indigenous species of land birds were recorded in the historic period, all small arboreal passerines of the tribe Drepanidini. Of a total of 163 known island populations of endemic species of land birds, 82, or 50%, became extinct prehistorically, and 31, or 19%, became extinct historically, for a total of 113 (69%).

Archaeological deposits on remote and supposedly pristine Henderson Island in the Pitcairn group show that the island was once inhabited by Polynesians, who exterminated at least two species of pigeons, representing 33% of the total known land bird fauna, of which four species are still extant. These two species of pigeons are the same as, or very closely related to, species known historically from the distant Society and Marquesas groups (Steadman and Olson 1985).

Bones of pigeons, parrots, and flightless rails from Holocene cave deposits on the island of Mangaia in the Cook group have raised the number of species of land birds known on that island from two to ten, so that 80% of the fauna became extinct prehistorically (Steadman 1985, in press). Most impressive are Steadman's (in press) recent discoveries of extinct species of rails, pigeons, and parrots in purely archaeological sites on four of the thirteen islands of the Marquesas. Only eleven species of native land birds were known previously from the Marquesas, but the archaeological deposits now add at least seven species to the total, for a minimum avifaunal loss of 39% for the whole archipelago. Many of the species from these archaeological sites are not yet extinct but do not occur on the islands where their bones were found. The islands of Hiva Oa, Tahuata, and Ua Huka each have only four historically known species of birds, whereas the fossil record adds five, six, and nine species, respectively, to these islands, for local extinction rates of 55 to 69%.

On the island of Huahine in the Society group, only a kingfisher (*Halcyon*) and a warbler (*Acrocephalus*) are known historically, whereas bones from archaeological sites have now added at least seven species of rails, pigeons, parrots, and passerines, for an extinction rate of 78% (Steadman, in press). Other extinct species or populations of birds have been documented from archaeological sites in Tonga, Fiji, Wallis, Tikopia, and the Santa Cruz Islands.

Extinctions of birds following in the wake of European explorations in the fifteenth and sixteenth centuries have been documented both historically and paleontologically on islands in the Indian and Atlantic Oceans. The fate of the fauna of the Mascarenes, home of the dodo and the solitaire, which were large flightless pigeons, is all too familiar. On the small island of St. Helena in the South Atlantic, only one native species of land bird has survived, whereas fossil remains show that at least four others were probably present when humans first arrived in 1502 (Olson 1975). Many vertebrate extinctions have been documented in the West Indies, although good chronologies are lacking, so it is difficult to sort out environmental from human-induced factors. Nevertheless, we have documented through the fossil record drastic changes in the composition of vertebrate faunas of the Lesser Antilles that have taken place within the past 2,000 to 3,000 years, and these are almost certainly the result of man's interference (Steadman et al. 1984).

Although I have stressed land birds, the effects of man on seabirds have been just as dramatic. We know of the extinction by man of certain species of seabirds, as on St. Helena (Olson 1975), but most of the reductions have been in numbers and sizes of populations. The effects of man-caused removal of millions of individual predators from oceanic ecosystems within the past 2,000 years have never been calculated but should be of concern to fisheries biologists and others.

Organisms other than birds must necessarily have been affected by the nearly complete conversion of lowland habitats to agriculture throughout Oceania and elsewhere in the world. The only extensive evidence from the prehistoric record for anything other than vertebrates comes from land snails, where the same pattern of massive extinctions is discerned (see, for example, Christensen and Kirch 1986). Insects, other invertebrates, and plants have doubtless been just as severely affected. When extrapolation is attempted from the paleontological data, it must always be remembered that fossil faunas are almost invariably incomplete. The data I have presented here are only minima, and the degree of extinction is always greater, sometimes much more so, than indicated by fossils.

The fossil record has shown that most biogeographical data based only on the historic record of islands are so misleadingly incomplete as to be all but useless for determining species/area curves or the natural distributions of individual species. Theoretical studies of island biogeography founded on such data, including studies that have been used in planning reserves in continental areas, are thus not likely to be particularly accurate or meaningful (Olson and James 1982; Steadman 1986).

It is still too early to make any realistically quantified estimate of the impact of man on insular ecosystems. Too few islands have been sampled paleontologically, and, as noted, most samples are still quite incomplete. However, we can consider some examples that are illustrative of the scale of extinctions. Endemic species of flightless rails doubtless occurred on virtually every oceanic island in the world, with some islands having two or more species. Extrapolating from the number and size of islands in Oceania, we may expect that hundreds of species of flightless rails have been exterminated in the Pacific in the past 2,000 years or less. Exclusive of continental islands, New Zealand, and the Solomons, only fourteen species of flightless rails, of all the hundreds predicted, were recorded in the historic period in the Pacific, and all but three of these are already probably extinct.

About one-third of all the species of birds in the world are endemic to islands, and this figure is probably considerably underestimated by application of the so-called biological species concept, in which distinctive allopatric populations are considered as subspecies rather than full species. From the fossil record it is clear that species diversity of birds on virtually all oceanic islands was reduced by 30 to 50%, and sometimes much more, within the period of man's occupancy. Thus, perhaps as much as one-quarter of all recent avian species were eradicated within an instant of geological time. Add to this the thousands of extinctions of other vertebrates, land snails, insects, and plants that must have taken place contemporaneously, coupled with historically documented extinctions, and we are faced with one of the swiftest and most profound biological catastrophes in the history of the earth.

Unlike tropical rain forests, this catastrophic reduction in species diversity is not something that is projected into the future—it has already happened—and the remnants of insular biotas are continuing to be depleted at a very rapid pace. Previously it was thought that high islands had greater species diversity because of their montane rain forests. An important observation to emerge from recent studies, however, is that drier, more level, lowland habitats, the ones most susceptible to burning and clearing for agriculture, had greater species diversity than steep areas of high, wet forests. On islands, most species that persist in wet montane forests today do so not because this is their preferred habitat, but because it is the only habitat left that has not been too severely modified by man (see discussion in Olson and James 1982:42–49).

Can this knowledge be applied to continental areas as well? Have we perhaps underestimated the diversity of mesic and arid environments in the tropics for lack of appreciation of the prehistoric influence of man? These environments, as on islands, are more susceptible to alteration by man than are rain forests, and their biotas may have experienced as yet undocumented prehistoric man-caused extinctions. Campbell (1979) has shown that the desert west coast of South America harbored an extensive endemic avifauna that has largely disappeared since the end of the Pleistocene. These extinctions have been tied to climatic deterioration and increasing desertification, processes that have extended into the Holocene and up to the present, but that were also coincident with the arrival of man in that part of the continent. Can we really rule out the possibility that increased burning by man in habitats adapted to very little rainfall may have exacerbated and accelerated the process of extinction at the same time that the biota of the Pacific coast of South America was enduring climatic stress?

It seems to me that a historical perspective and much better knowledge of Pleistocene environments is absolutely essential to planning large-scale conservation efforts in South America. It is increasingly evident that neotropical rainforests are much less stable and of much younger origin than has long been thought (Campbell and Frailey, 1984). During the last glacial period, rain forests were greatly reduced in area, whereas the dominant habitat type was probably mesic or arid savanna (Lewin 1984). In some cases, areas that had been postulated as forest refugia were shown to have been savanna in the Pleistocene. Because the great biological diversity of South American rain forests about which we marvel today was sustained throughout the period when such habitats were much less extensive than at present, is it not essential to try to determine the location and extent of the late Pleistocene rain forests as a model for preserving modern diversity? And should we not also be equally concerned about conservation of habitats other than rainforest, which may be even more "fragile" and in the past may have been much more diverse?

Fossils have shown that the human-induced biological catastrophe predicted as the future of tropical rain forests has long been underway on islands and perhaps in less humid continental areas as well. From such studies it is increasingly evident that the element of time, the paleontological record, and human history are essential factors that must be woven into the fabric of any successful strategy for conservation.

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