Haberle et al. (1991:30, 38) and Brookfield (1991:207) contrast the situation in the Irian Jaya section of the Highlands, where no volcanic ash is present and the land is more susceptible to degradation and erosion. Brookfield (1991:207) describes the intensively managed and densely peopled wetlands of the Baliem Valley and Paniai lakes as being separated by a wide expanse of sparsely populated degraded slopeland from agrarian settlements in tributary valleys and at the forest edge.

CONCLUSION

The massive transformation that the practice of shifting cultivation wrought in the ecology of Highlands New Guinea—from which we have derived some basic features of Highlands societies—as well as in agricultural practice, pig husbandry, and systems of exchange, took place over many millennia. The entry of the sweet potato was a fairly recent event, and it brought about changes in settlement and pig husbandry whose ramifications were still being worked out at the time of European contact. Today, in the Papua New Guinea Highlands the cash economy and rising populations are making new demands on natural and social systems and are requiring adjustments from them of a scale and urgency unparalleled in the past.

4

Extinctions of Polynesian Birds: Reciprocal Impacts of Birds and People

David W. Steadman

The loss of bird life is now well recognized as one of the major environmental consequences of the human colonization of Oceania. The decline of birds is related mainly to predation and to landscape changes wrought by prehistoric peoples to accommodate agriculture. For birds, perhaps the most influential landscape change has been the elimination and alteration of indigenous forests through cutting, burning, and the introduction of nonnative plants (Kirch 1983). These activities have eliminated natural habitats and have rendered the surviving birds even more vulnerable to predation from humans and nonnative mammals (rats, dogs, pigs). The erosion of topsoil associated with deforestation has removed large areas of nesting habitat for burrowing seabirds, such as shearwaters and petrels.

Ethnographic information gathered over the past two centuries is crucial for interpreting Polynesian uses of birds in prehistoric times. I shall concentrate as much as possible on the prehistoric and early historic relationships between birds and Polynesians, knowing that events of the post-European period have only exacerbated what already was a dismal situation from the birds' standpoint.

The geographic area considered here is all of Polynesia except the Hawaiian Islands and New Zealand. Although Hawaii (Olson and James 1982a, 1982b, 1991; James and Olson 1991; James et al. 1987) and New Zealand (Anderson 1984, 1989a; Cassells 1984; Trotter and McCulloch 1984; Holdaway 1989) both experienced major prehistoric losses of birds, the biotas of these two isolated archipelagoes are not closely related to those elsewhere in Polynesia.

The prehistoric record of birds is much better known in Polynesia than in Micronesia or Melanesia. Bones of birds from archaeological or paleontological contexts are now known from at least 20 Polynesian islands besides Hawaii and New Zealand. In Micronesia, studies have been completed thus far on only two islands. From Rota in the Mariana Islands, several small cave deposits have yielded bones of 13 species of extinct or extirpated birds, including shearwaters, terns, ducks, megapodes, rails, pigeons, parrots, swifts, and passerines (Steadman 1992a). Assemblages of archaeological bird bones excavated on Fais (Yap) represent species of indigenous resident birds, 12 of which probably or certainly no longer live on Fais (Steadman and Intoh 1994). In spite of the small amount of data currently available from Micronesia, I see no cultural, geographical, or biological reason why the extent of human-caused avian extinctions in this region of Oceania, when more fully studied, will differ in any major way from that of Polynesia.

The islands of Melanesia tend to be larger, and to support richer floras and faunas today, than the islands of Polynesia or Micronesia. The prehistoric record of Melanesian birds has been studied only on Fiji (Steadman 1989b), New Caledonia (Balouet and Olson 1989), New Ireland (Steadman, White, and Allen n.d.), and Mussau (Steadman n.d.). As in Polynesia and Micronesia, the limited record in Melanesia shows losses of a variety of both seabirds and landbirds, the latter dominated by hawks, megapodes, rails, pigeons, parrots, and owls but also including herons, ibises, buttonquails, snipe, owlet-nightjars, and crows. Preliminary data from the very large, high island of New Ireland indicate that even its relatively rich avifauna (currently about 108 species of resident landbirds) has lost about 25% of its species. A greater percentage of birds has survived on the larger islands of Melanesia than on typical Polynesian or Micronesian islands, or on small Melanesian islands. This seems to be due to the buffering effects that large island size, steep terrain, and diseases (such as malaria) have had on human impact. Common sense dictates that insular floras and faunas are easiest to deplete on low, small islands. In addition, many parts of island Melanesia have been occupied for tens of millennia longer than anywhere in Polynesia or Micronesia (Jones 1989; see Chapter 2, this volume).

HUMAN IMPACTS ON BIRDS

Background Extinction

The Holocene extinction of vertebrates on Oceanic islands has been calibrated by the fossil record of the Galápagos Islands (Steadman et al. 1991). Unlike any other group of islands in the tropical Pacific, the Galápagos never supported human populations before their discovery by Europeans in 1535 (Steadman 1986). As a result, human impact in the Galápagos is confined to the past five centuries, and it was relatively minor until about 1800. The Holocene fossil record of the Galápagos comprises about 500,000 bones, more than 90 percent of which predate the arrival of humans. These paleofaunas reveal the loss of only zero to three vertebrate populations in the 4,000 to 8,000 years before human arrival, compared to the loss of 21 to 24 populations in the past 150 to 300 years. Thus the rate of background (prehuman) extinction in the Galápagos was at least a hundred times less than the rate of human-related extinction. When undisturbed by humans, the natural processes of dispersal, colonization, and evolution may result in a very low rate of extinction for reptiles, birds, and mammals on tropical Oceanic islands.

The Polynesian Record

Moving west from the Galápagos to Oceania, we find that virtually all islands were inhabited at one time or another in prehistory and that a significant amount of prehistoric extinction has taken place. The prehistoric record of Polynesian birds is based on data collected from archaeological and paleontological sites in the Marquesas Islands (Steadman 1988, 1989a, 1991a, 1992b; Steadman et al. 1988; Steadman and Zarriello 1987; Dye and Steadman 1990), the Society Islands (Steadman 1989a, 1992b; Dye and Steadman 1990; Steadman and Pahlavan 1992), the Cook Islands (Steadman 1985, 1987, 1989a, 1991b, 1992b; Allen and Schubel 1990; Allen and Steadman 1990, Steadman and Kirch 1990; Kirch et al. 1991; Kirch et al. 1992), Henderson Island (Steadman and Olson 1985; Schubel and Steadman 1990), Easter Island (Steadman et al. 1994), Samoa (Steadman 1993b), Tonga (Steadman 1989a, 1989b, 1993a; Dye and Steadman 1990), and the Polynesian Outliers in Melanesia (Balouet and Olson 1987; Steadman et al. 1988; Steadman, Pahlavan, and Kirch 1990). I shall review this record briefly, using specific examples from several island groups.

The losses of birds in Polynesia fall into three categories: (1) extinction (loss of all populations of a species); (2) extirpation (loss of a species on an individual island, although one or more populations of the species survive elsewhere); and (3) reduced population (loss without replacement of individuals

from a surviving population on an island). A single locality (Mangaia, the Cook Islands) can exemplify each category. The Conquered Lorikeet (*Vini vidivici*) is *extinct* because it has been exterminated on Mangaia as well as on every other island where it ever occurred. The Society Islands Pigeon (*Ducula aurorae*) is *extirpated* on Mangaia (and several other islands) but survives on Makatea (Tuamotus) and Tahiti. Audubon's Shearwater (*Puffinus lherminieri*), a pantropical seabird, has a *reduced population* on Mangaia today, surviving in numbers of less than 100, whereas archaeological and ethnographic evidence suggests that once it was common and widespread on the island.

The loss of seabirds in Polynesia has been particularly severe for petrels and shearwaters, although the ranges and numbers of many other kinds of tropical seabird (various albatrosses, storm-petrels, tropicbirds, frigatebirds, boobies, terns, gulls) have been reduced as well. The losses of landbirds in Polynesia have been greatest for rails, pigeons, doves, and parrots, although, as with the seabirds, no family of landbirds has been spared. In Western Polynesia, unlike Eastern Polynesia, the losses of landbirds also include herons, megapodes, hawks, shrikebills, whistlers, monarch flycatchers, thrushes, white-eyes, and honeyeaters, some of which represent taxa previously occurring only in Melanesia, not in Polynesia. By eliminating the "Melanesian" taxa, the anthropogenic extinction of birds in Tonga, for example, has artificially sharpened the biogeographic distinction between the avifaunas of Polynesia and Melanesia (Steadman 1993a).

Quite deservedly, the "biodiversity crisis" has received much popular and scholarly attention in the past decade. An understanding of the current biodiversity crisis requires proper historic perspective, which in turn tells us that few places on earth have escaped environmental change at the hands of prehistoric humans. From the standpoint of numbers of extinct species, the most dramatic story is that of flightless rails. Each island in the tropical Pacific with a thorough prehistoric record of birds has yielded the bones of one to three unique (endemic) species of flightless or nearly flightless rails. At least five genera are involved, *Porzana, Gallirallus, Nesoclopeus, Gallinula,* and *Porphyrio,* with *Gallirallus* providing the most species discovered thus far and one of the world's most exciting, albeit least understood, examples of adaptive evolutionary radiation. About 800 islands in Oceania are inhabitable by people and therefore, presumably, by flightless rails. Thus rails alone might account for as many as 2,000 species of birds that would exist today had people not colonized Oceania.

The first of several examples of depleted Polynesian avifaunas is from Ua Huka in the Marquesas Islands (Table 4.1), where the Hane site has yielded

Table 4.1 Resident Birds from Ua Huka, Marquesas Islands

	Bones from Hane Site	Exists today on Ua Huka
SEABIRDS		
Wedge-tailed Shearwater (*Puffinus pacificus*)	x	x
Christmas Island Shearwater (*Puffinus nativitatis*)	x	—
Audubon's Shearwater (*Puffinus lherminieri*)	x	—
Bulwer's Petrel (*Bulweria* cf. *bulwerii*)	x	x
Tahiti Petrel (*Pterodroma rostrata*)	x	—
Phoenix Petrel (*Pterodroma* cf. *alba*)	x	—
Unknown petrel (*Pterodroma* small sp.)	x	—
Polynesian Storm-Petrel (*Nesofregetta fuliginosa*)	x	x
White-bellied Storm-Petrel (*Fregetta grallaria*)	x	—
White-tailed Tropicbird (*Phaethon lepturus*)	x	x
Red-footed Booby (*Sula sula*)	x	x
Brown Booby (*Sula leucogaster*)	x	x
Masked Booby (*Sula dactylatra*)	x	—
Abbott's Booby (*Papasula abbottii costelloi*)	x	—
Great Frigatebird (*Fregata minor*)	x	x
Lesser Frigatebird (*Fregata ariel*)	x	x
Gray-backed Tern (*Sterna lunata*)	—	x
Sooty Tern (*Sterna fuscata*)	x	x
Brown Noddy (*Anous stolidus*)	x	x
Black Noddy (*Anous minutus*)	x	x
Blue-gray Noddy (*Procelsterna cerulea*)	—	x
Little Fairy Tern (*Gygis microrhyncha*)	x	x
LANDBIRDS		
Pacific Reef-Heron (*Egretta sacra*)	x	x
Tuamotu Sandpiper (*Prosobonia* cf. *cancellata*)	x	—
°Undescribed crake (*Porzana* new sp.)	x	—
°Undescribed rail (*Gallirallus* new sp.)	x	—
Marquesas Ground-Dove (*Gallicolumba rubescens*)	x	—
°Giant Ground-Dove (*Gallicolumba nui*)	x	—
Red-moustached Fruit-Dove (*Ptilinopus mercierii*)	x	—
White-capped Fruit-Dove (*Ptilinopus dupetithouarsii*)	x	x
Nuku Hiva Pigeon (*Ducula galeata*)	x	—
°Marquesas Cuckoo-Dove (*Macropygia heana*)	x	—
Marquesas Lorikeet (*Vini ultramarina*)	x	—
°Conquered Lorikeet (*Vini vidivici*)	x	—
°Sinoto's Lorikeet (*Vini sinotoi*)	x	—
Marquesas Swiftlet (*Collocalia ocista*)	—	x
Marquesas Kingfisher (*Halcyon godeffroyi*)	x	—

Table 4.1 (continued)

	Bones from Hane Site	Exists today on Ua Huka
°Undescribed monarch (cf. *Myiagra* new sp.)	x	—
Iphis Monarch (*Pomarea iphis*)	—	x
Marquesas Reed-Warbler (*Acrocephalus mendanae*)	—	x
TOTALS		
Total species of seabirds	20	14
Combined total species of seabirds	22	
Total species of landbirds	15	5
Combined total species of Landbirds	18	

SOURCE: Modified from Steadman 1991a
° = extinct species

about 11,000 bird bones, the largest avian assemblage yet obtained from tropical Polynesia. Most of these bones represent seven species of shearwaters and petrels, easily obtained from their nesting burrows. While six of the 20 species of seabirds from the Hane site no longer occur on Ua Huka, this number alone does not represent the loss of seabirds. Most of the 14 species of seabirds listed in Table 4.1 as "exists today on Ua Huka" nest today not on the main island but only on tiny offshore islets. Even the surviving species of seabirds exist on Ua Huka or its islets in much reduced numbers.

Pigeons and doves (family Columbidae) are the most common landbirds at the Hane site, both in terms of number of species and number of bones. Only one of the six species of columbids in the Hane deposits survives today on Ua Huka. Rails and parrots are the next most common, each of these families having declined on Ua Huka from three to zero species. Although the exact chronology of the Hane site is in dispute (Sinoto 1979; Kirch 1986), the pattern of avian exploitation is clear (Dye and Steadman 1990:212): "The relative contribution of birds to the diet [more than half of all animal protein in the early period] is more than halved within the first 550 years and declines to insignificance in just over a thousand years."

The second example of a prehistoric avifauna is from the Fa'ahia site on Huahine in the Society Islands (Table 4.2). This assemblage is extremely rich in species, considering that it is based on only 336 identified bird bones. All but three of the 14 species of seabirds recorded from Fa'ahia occur at the Hane site as well. The species-level similarity among landbirds is much less striking, with only three species shared. Again, rails, pigeons, doves, and par-

Table 4.2 Resident Birds from Huahine, Society Islands

	Bones from Fa'ahia Site	Exists today on Huahine
SEABIRDS		
Wedge-tailed Shearwater (*Puffinus pacificus*)	x	—
Christmas Island Shearwater (*Puffinus nativitatis*)	x	—
Audubon's Shearwater (*Puffinus lherminieri*)	x	—
Tahiti Petrel (*Pterodroma rostrata*)	x	—
Phoenix Petrel (*Pterodroma alba*)	x	—
Herald Petrel (*Pterodroma arminjoniana*)	x	—
White-tailed Tropicbird (*Phaethon lepturus*)	x	x
Red-footed Booby (*Sula sula*)	x	—
Brown Booby (*Sula leucogaster*)	x	—
Great Frigatebird (*Fregata minor*)	x	—
Lesser Frigatebird (*Fregata ariel*)	x	—
°Undescribed gull (*Larus* new sp.)	x	—
Brown Noddy (*Anous stolidus*)	x	x
Black Noddy (*Anous minutus*)	—	x
Common Fairy Tern (*Gygis candida*)	x	x
LANDBIRDS		
Pacific Reef-Heron (*Egretta sacra*)	x	x
Mangrove Heron (*Ardeola striata*)	x	—
Gray Duck (*Anas superciliosa*)	—	x
Sooty Crake (*Porzana tabuensis*)	x	—
°Undescribed rail (*Gallirallus* new sp.)	x	—
Society Islands Ground-Dove (*Gallicolumba erythroptera*)	x	—
°Giant Ground-Dove (*Gallicolumba nui*)	x	—
Society Islands Fruit-Dove (*Ptilinopus purpuratus*)	x	x
Nuku Hiva Pigeon (*Ducula galeata*)	x	—
Society Islands Pigeon (*Ducula aurorae*)	x	—
°Huahine Cuckoo-Dove (*Macropygia arevarevauupa*)	x	—
Society Islands Lorikeet (*Vini peruviana*)	—	e
°Conquered Lorikeet (*Vini vidivici*)	x	—
°Sinoto's Lorikeet (*Vini sinotoi*)	x	—
Tahiti Swiftlet (*Collocalia leucophaea*)	—	e
Chattering Kingfisher (*Halcyon* cf. *tuta*)	x	x
Society Islands Reed-Warbler (*Acrocephalus caffer*)	x	e
Huahine Starling (*Aplonis diluvialis*)	x	e

Table 4.2 (continued)

	Bones from Fa'ahia Site	Exists today on Huahine
TOTALS		
Total species of seabirds	14	4
Combined total species of seabirds	15	
Total species of landbirds	15	4
Combined total species of landbirds	18	

SOURCE: Modified from Steadman and Pahlavan 1992
* = extinct species
e = recorded in nineteenth century but now extirpated

rots predominate in the prehistoric avifauna. Except for bone assemblages recently collected with screens of $\frac{1}{16}$ inch mesh on Aitutaki and Mangaia (Allen and Steadman 1990; Steadman and Kirch 1990), all of the Eastern Polynesian faunal assemblages are biased toward larger species of bird. (Screens of $\frac{1}{8}$ inch mesh remove most, but not all, of this bias.) Thus tiny species, such as swifts and many passerines, typically are absent or underrepresented. To the west, in Tonga, we now know through sampling with screens of $\frac{1}{16}$ inch that passerines underwent losses comparable to those of larger landbirds (Steadman 1993a).

The prehistoric exploitation of birds can be examined from a more detailed chronostratigraphic perspective at Tangatatau Rockshelter (site MAN-44) on Mangaia in the Cook Islands (Table 4.3). This stratified site ranges from about 900 (zone J) to 200 or 300 years old (zone A). During this period, the human consumption of vertebrates underwent dramatic change. Domesticates (the pig, *Sus scrofa,* and chicken, *Gallus gallus*) are rare in lower strata but increase as native landbirds decrease. Both pig and chicken decline, however, in the uppermost strata, perhaps because of overconsumption by a relatively large human population.

The number of bones from native birds—that is, all species except chickens—is high in zones I and J, low in the middle zones, and high again in zones B and C. The species composition, however, is different between the early and late zones. Extinct or extirpated species of landbirds dominate zones G to J, while seabirds, especially the Black-winged Petrel (*Pterodroma nigripennis*), account for the late increase in exploitation of birds. This differs from sites elsewhere in Polynesia, such as the Marquesas, the Society Islands,

Table 4.3 Vertebrate Faunal Summary by Analytic Zones (A to J), Main Trench (Squares C30 to G30), Tangatatau Rockshelter (MAN-44), Mangaia, Cook Islands, July to August 1989

TAXON	A	B	C	D	E	F	G	H	I	J	TOTAL
FISH	51	667	973	937	2,464	1,206	875	735	1,379	80	9,367
REPTILES											
Sea turtle	1	—	—	1	—	—	—	—	—	—	2
Lizard	—	1	—	—	—	—	1	—	3	—	5
BIRDS											
All native species	7	27	22	4	7	1	9	13	49	47	186
Gallus gallus	1	—	2	3	13	3	6	—	3	—	31
Unidentifiable bird	5	27	20	10	23	4	11	13	36	52	201
MAMMALS											
Pteropus tonganus	—	—	—	—	—	—	1	2	15	13	31
Rattus exulans	19	125	83	50	39	14	61	34	40	1	466
Sus scrofa	—	—	3	10	13	2	1	1	1	—	31
Delphinidae sp.	—	—	—	—	—	—	1	—	—	—	1
Homo sapiens	1	1	—	—	—	—	—	—	—	—	2
Unidentifiable mammal	—	2	—	2	4	2	1	—	—	—	11
Unidentifiable bone	—	5	3	—	12	2	—	4	11	—	37
TOTALS											
All species	85	855	1,106	1,017	2,575	1,234	967	803	1,535	191	10,366
All nonfish	34	188	133	80	111	28	92	67	158	113	1,004
% nonfish	40.0	22.0	12.0	7.9	4.3	2.3	9.5	8.4	10.3	59.2	9.6
% fish	60.0	78.0	88.0	92.1	95.7	97.7	90.5	91.6	89.6	41.9	90.4

SOURCE: From Steadman and Kirch 1990

Tonga, and Tikopia, where bones of seabirds are more abundant than those of landbirds in the oldest cultural levels of early sites (Steadman 1989a, 1989b; Dye and Steadman 1990; Steadman et al. 1990). A factor on Mangaia may be its precipitous, creviced limestone cliffs, which provided an extensive albeit narrow band of relatively rat-free nesting habitat for seabirds.

Based upon number of bones, predation on landbirds at MAN-44 was most intense in zones I and J and tapered off to practically nil by the end of zone G (Table 4.4). Based on relative abundance of bones (percentage of all vertebrates), predation on landbirds was by far most intense in zone J, after which most species survived into zones I, H, or G, but only in reduced numbers. No extinct or extirpated landbirds are recorded above zone G except the Cook Islands Fruit-Dove (*Ptilinopus rarotongensis*), which still survives on Rarotonga and Atiu and is known historically from Ma'uke and Aitutaki.

Conforming to the general Eastern Polynesian pattern, the eight species of extinct or extirpated landbirds from MAN-44 consist of rails, pigeons, doves, and parrots. Both of the extinct rails were flightless. Their obligatory existence on the ground for foraging and nesting must have facilitated predation by humans and rats. Pigeons, doves, and parrots are forest species favored as food by Polynesians. Parrots (and sometimes pigeons and doves) also were used for their brightly colored feathers, as I discuss below.

The five surviving species of landbirds recorded from MAN-44 are those that can withstand substantial forest clearance. Because they prefer marshes or dense growths of ferns, grasses, and sedges, the Gray Duck (*Anas superciliosa*) and the Sooty Crake (*Porzana tabuensis*) have probably benefited from anthropogenic landscape changes that promote irrigated taro cultivation. The Lesser Golden-Plover (*Pluvialis dominica*) is a migratory shorebird that nests only on the tundra of high northern latitudes. In Polynesia it occurs in open habitats like reefs and sand flats, grassy fields, and airstrips. The Mangaia Kingfisher (*Halcyon mangaia*) seems to tolerate moderate forest clearance but requires cavities in trees for nesting. Its current scarcity on Mangaia may be related to nest-site competition with the Common Myna (*Acridotheres tristis*), an abundant and aggressive Asian species introduced to Mangaia earlier this century. The Mangaia Reed-Warbler (*Acrocephalus kerearako*) occurs in forests, thickets, and shrublands of varying disturbance and maturity.

Hunting Methods

On many Polynesian islands today, birds are hunted with shotguns. Prehistoric Polynesians were highly skilled at catching birds by traditional methods, which are still used on some islands. Boys today (and presumably in the past) begin to

hunt birds at a young age and often continue to hunt nearly throughout their lives. I have learned from personal experience that certain boys and young men can climb cliffs with amazing skill, speed, and fearlessness (to grab birds, especially tropicbirds and terns), can throw rocks at birds with deadly speed and accuracy, and may virtually run up a large tree to grab a nesting bird.

Perhaps the most common way that prehistoric Polynesians caught birds was simply by hand. The hand method of gathering birds, known as *tangotango* on Tikopia and *tango manu* on Pukapuka (Beaglehole and Beaglehole 1938:74), is rather straightforward: you simply "see a bird dozing in a tree, climb up behind it, grab it, and break its neck" (Feinberg 1981:34). Sticks are used to strike birds in trees, along shorelines, and on cliffs. Seabirds are particularly vunerable. Some species of tropicbirds, boobies, and terns, for example, nest on the ground, while most species of shearwaters and petrels nest in burrows or crevices. Any of these seabirds could (and still can) be plucked from their resting places just by reaching down or in and grabbing them. One such bird on Mangaia was the *titi*, probably a yet to be determined species of shearwater (*Puffinus* sp.) that no longer seems to exist on the island. In describing the eating habits of two late prehistoric fugitives living in the Mangaian forest, Gill (1894:26) stated: "The bird most easily caught by [the fugitives] Uriitepitokura and Temoaakaui was the *titi* (so called from its cry). In the month of December it leaves its burrowings in the red mountain soil, and comes to the rocks near the sea to fatten its young on small fish. By day it hides in holes, and sleeps. The hunter has only to call at the entrance to the dark cave, in a plaintive voice, *E titi e*, when the foolish bird, imagining it to be the voice of its mate, comes out of its secure hiding-place, and, dazzled by the unwelcome light, allows itself to be caught by hand." In a Mangaian dirge, a defenseless titi is compared to an unarmed man facing a man with a war club (Gill 1894:307).

Another example of predation on a defenseless seabird is Gill's description (1885:108–9) of the Herald Petrel (*Pterodroma [arminjoniana] heraldica*):

> A fishing-hawk, about the size of a pigeon, with black eyes and dark plumage, excepting underneath, where it is white, was formerly plentiful at Rarotonga [where it still survives; McCormack and Kunzle 1990b]. Its home is in the crannies of almost inaccessible rocks. The *koputu* (such is its name) lays but two eggs—exactly like those of a duck in size and color—in the season. It is considered by the natives to be excellent eating. A favorite pastime of young men in the olden time was to catch these birds in the breeding season at the risk of their lives. The plan was to lower a lad over the edge of a cliff with a stout coir rope round his waist, the upper end passed round the trunk of a tree and firmly grasped by a near relative [usually a brother, as distant relatives were not trusted]. A basket slung round the neck would soon be filled with dead birds and the lad hauled up again.

Table 4.4 Summary of Birds by Analytic Zones (A to J), Main Trench (Squares C30 to G30), Tangatatau Rockshelter (MAN-44), Mangaia, Cook Islands, July to August 1989

TAXON	A	B	C	D	E	F	G	H	I	J	TOTAL
SEABIRDS											
Audubon's Shearwater (*Puffinus lherminieri*)	—	1	2	—	—	—	—	—	—	—	3
°Black-winged Petrel (*Pterodroma nigripennis*)	3	17	14	2	1	—	—	—	—	—	37
Unidentified petrel or shearwater (Procellariidae sp.)	—	—	—	—	1	—	—	—	—	—	1
Polynesian Storm-Petrel (*Nesofregetta fuliginosa*)	1	—	—	—	1	—	—	—	—	—	2
White-tailed Tropicbird (*Phaethon lepturus*)	—	1	1	—	—	—	1	—	1	1	5
Lesser Frigatebird (*Fregata ariel*)	—	2	3	2	—	—	—	—	—	—	7
Brown Noddy (*Anous stolidus*)	1	—	2	—	—	1	—	—	—	—	4
Blue-gray Noddy (*Procelsterna cerulea*)	—	—	—	—	—	—	—	—	1	—	1
Common Fairy Tern (*Gygis candida*)	—	—	—	—	1	—	—	1	3	1	6
°Little Fairy Tern (*Gygis microrhyncha*)	—	—	—	—	—	—	—	—	1	—	1
LANDBIRDS											
Gray Duck (*Anas superciliosa*)	1	5	—	—	3	—	—	—	—	—	9
Lesser Golden-Plover (M) (*Pluvialis dominica*)	—	—	—	—	—	—	—	—	1	—	1
Chicken (I) (*Gallus gallus*)	1	—	2	3	13	3	6	—	3	—	31
°°Ripley's Rail (*Gallirallus ripleyi*)	—	—	—	—	—	—	2	3	7	6	18
Sooty Crake (*Porzana tabuensis*)	—	—	—	—	—	—	1	—	—	—	1
°°Mangaian Crake (*Porzana rua*)	—	—	—	—	—	—	—	2	13	11	26
°Society Islands Ground-Dove (*Gallicolumba erythroptera*)	—	—	—	—	—	—	—	—	4	3	7
°°Giant Ground-Dove (*Gallicolumba nui*)	—	—	—	—	—	—	—	—	—	1	1
°Cook Islands Fruit-Dove (*Ptilinopus rarotongensis*)	—	1	—	—	—	—	—	—	1	1	3
°Nuku Hiva Pigeon (*Ducula galeata*)	—	—	—	—	—	—	1	—	1	2	4
°Rimatara Lorikeet (*Vini kuhlii*)	—	—	—	—	—	—	2	3	5	10	20
°°Conquered Lorikeet (*Vini vidivici*)	—	—	—	—	—	—	2	3	5	9	19
°Rimatara or °°Conquered Lorikeet (*Vini kuhlii* or *V. vidivici*)	—	—	—	—	—	—	—	1	4	2	7
Mangaia King fisher (*Halcyon mangaia*)	1	—	—	—	—	—	—	—	—	—	1
Mangaia Reed-Warbler (*Acrocephalus kerearako*)	—	—	—	—	—	—	—	—	2	—	2
TOTALS											
All species	8	27	24	7	20	4	15	13	52	47	217
All native species	7	27	22	4	7	1	9	13	49	47	186
Seabirds	5	21	22	4	4	1	1	1	6	2	67
Native landbirds	2	6	—	—	3	—	8	12	43	45	119
Extinct or extirpated landbirds	—	1	—	—	—	—	7	12	40	45	105
Extinct or extirpated landbirds as % of all vertebrates	0	0.1	—	—	—	—	0.7	1.5	2.5	24	
Extinct or extirpated landbirds as % of all nonfish	—	0.5	—	—	—	—	8	18	24	41	—
Extinct or extirpated landbirds as % of all birds	—	4	—	—	—	—	47	86	77	98	—

SOURCE: From Steadman and Kirch 1990
I: Introduced species
M: Migrant species
° Extant species extirpated on Mangaia
°° Extinct species

Gathering eggs of wild birds, particularly of seabirds, was another popular activity throughout Polynesia. By contrast, eggs of chickens seem to be shunned in many places, both today and in the past. Small, uninhabited islands were often visited to gather seabirds and their eggs. Among the many examples are Marquesans visiting Hatutu, Motu Iti, and Fatuhuku, Tahitians visiting Mopelia, Easter Islanders visiting Motu Nui, Mangaians and Aitutakians visiting Manuae, Atiuans visiting Takutea, Ma'ukeans visiting Maria, 'Euans visiting Kalau, and the Tikopia and Anuta visiting Fatutaka (see Dening 1963:121, 122). The relative abundance of seabirds on uninhabited islands provides an important clue to the role birds played in locating islands (discussed below).

On Mangaia, groups of men and boys often weed a taro field inwardly from all sides. Although volant, the Sooty Crake, or mo'o mo'o, is reluctant to fly. Thus several mo'o mo'o may be concentrated by the workers into a weedy patch in the center of the field that is only about 2 m in diameter, at which point the birds can be caught by hand or hit with machetes.

Nets were commonly used to catch birds. On Tikopia, a long-handled net known as *te kupenga veu* was and still is used to catch petrels, noddies, and swifts (Steadman, Pahlavan, and Kirch 1990). Positioning themselves strategically along cliffs, hillsides, and elsewhere, the Tikopia call to entice birds within reach of the nets, which have handles 3 to 4.5 m long.

Snares were an effective way to catch birds on the ground as well as in the trees. They were usually made of saplings and sennit cordage (see Buck 1944: Fig. 155). The slip noose of sennit cordage (Gill 1885:90–91) is a variety of snare often used in fruiting trees to catch members of feeding flocks of starlings, fruit-doves, or pigeons. The futility of an ensnared bird is revealed on Mangaia in "The War-Dirge of Tuopapa," which reads in part:

> Descendants of Tirango, destroy your foes!
> They are but ensnared birds.
> They fly for their lives.
> Whither indeed shall the vanquished fly,—
> This vast host?
> Where can shelter be found, or life be safe?
> Can another stand be made? Is all hope gone? [Gill 1894:98]

Snares are still used occasionally. In 1988, I saw a Banded Rail (*Gallirallus philippensis*) snared by a 12-year-old boy on 'Eua, Tonga. Feral chickens, once commonly pursued with snares, are seldom hunted today because their flesh is less tender than that of tame chickens living in the yard. With the switch from subsistence to cash economies and the availability of electricity for freezers, even yard chickens are shunned if one can purchase and store the ultratender frozen chickens, already plucked and gutted, that are imported from New Zealand, Australia, or the United States, the same countries where people have begun to pay extra for "free-range" chickens and their eggs. Chickens need not cross the road to provide cross-cultural amusement.

Bird lime was an effective way to catch perching birds up to the size of pigeons (Gill 1885:90–91). This sticky substance was prepared by mixing the sap of breadfruit trees (*Artocarpus altilis*) with crushed, baked nuts of the candlenut tree (*Aleurites moluccana*). Bird lime was spread on limbs in places frequented by birds, whose feet would adhere to it. As with snares, trees heavily laden with fruit or flowers were targeted for bird lime.

Bows and arrows were used to kill birds in Samoa, including rails and pigeons (Muse and Muse 1982:83, 94). So far as I can determine, bows and arrows were of little or no importance for hunting birds elsewhere in Polynesia. Bub (1991: Fig. 173) illustrates a cage trap from Samoa that features a tethered Purple-capped Fruit-Dove (*Ptilinopus porphyraceus*) in a woven basket designed to catch more fruit-doves.

A specialized form of hunting the Pacific Imperial-Pigeon (*Ducula pacifica*) occurred in Tonga, Niue, and Samoa on large earthen "pigeon mounds" (called *sia heu lupe* in Tonga; *sia*—mound, *heu*—snare, *lupe*—pigeon; McKern 1929:19–21). Catching the pigeons involved nets of various sizes (or snares) and tethered pigeons (Loeb 1926:119; Bub 1991:207–8). It seems to have been more a sport for chiefs and nobles than a widespread method of hunting by commoners. The great importance of pigeons is indicated further by specialized words, such as the Samoan *mafu* (breast fat of pigeons), *matua'ie* (old and fat pigeon), and *tula* (decoy pigeon's perch; Milner 1966:119, 139, 285).

Finally, it should be noted that mammals introduced prehistorically to Polynesia preyed on native birds. Both dogs (*Canis familiaris*) and pigs must have killed ground-dwelling birds to some extent, although their impact may have been minor. Rats were far more important predators on the eggs, chicks, and adults of native seabirds and landbirds. Almost throughout Oceania, the Pacific or Polynesian Rat (*Rattus exulans*) was introduced prehistorically, either intentionally or as a commensal stowaway in voyaging canoes. In the past two centuries, the Black, Ship, or Roof Rat (*R. rattus*) and the Norway Rat (*R. norvegicus*), natives of Asia, have been spread unintentionally through much of Oceania. These aggressive species, particularly *R. rattus*, have displaced *R. exulans* on many islands. All three rats prey on island birds, although *R. exulans* does so less than the other two (Atkinson 1985). It is difficult to evaluate the prehistoric impact of *R. exulans* on native birds. Based in part on how abundantly their bones occur in carefully excavated archaeological sites,

the prehistoric populations of *R. exulans* may have been large, and they are likely to have been important predators on a variety of birds.

Although my main concern here is prehistory, I should mention that the period of European influence has brought some other nonnative predators to parts of Oceania, such as the cat (*Felis catus*) and mongoose (*Herpestes* sp.). Among the various European-introduced herbivores to tropical Oceania, the goat (*Capra hircus*) has probably done the most damage to natural habitats through over-browsing native plants and dispersing the seeds of nonnative plants.

Understanding the Survivors

The human occupation of tropical islands has been detrimental to a wide variety of birds, leading to the extinction of many species and the elimination or reduction of innumerable populations. So far, it would seem that the impact of humans on Polynesian birds has been almost unfailingly negative. Most of the surviving species are those that prefer open or wetland habitats (herons, ducks, volant rails, and migrant shorebirds) or that tolerate some level of forest clearance (certain fruit-doves, kingfishers, and warblers). Even many of these species are declining, and some seem destined to extinction within decades. There are, however, opportunities to reverse some of the losses of Polynesian landbirds, including the forest-loving species.

One strategy would be to translocate species onto islands that they previously occupied, after it has been determined that adequate habitat now is suitable and that current human activities are compatible (Franklin and Steadman 1991). Uninhabited islands are especially well suited for such programs. As Polynesians move to major population centers, many relatively remote islands are being abandoned by humans or are decreasing in population. The chances of success for bird translocations would be enhanced by good background knowledge of the species involved. Unfortunately, we do not know much about the ecology and behavior of the landbirds that survive in Polynesia. With but a few exceptions, data are lacking on the precise distributions, current population sizes, habitat preferences, and vulnerabilities of Polynesian birds.

Surveys like those conducted in American Samoa by Amerson et al. (1982a, b) should be undertaken at regular intervals throughout Polynesia. Detailed studies of nesting and food habits are lacking for most Polynesian landbirds. Where such studies have been carried out, as for the endangered Rarotongan Monarch [Flycatcher] or *kakerori* (*Pomarea dimidiata*), an effective conservation program was implemented (McCormack and Kunzle 1990a). Many other similar programs could be undertaken if more scientists,

and agencies that fund research, became seriously interested in Polynesian islands other than Hawaii and New Zealand.

Another topic for research would be to determine the potential impact on native birds of blood-borne parasites (hematozoa), especially those that cause avian malaria. These diseases are transmitted by dipterans (mosquitoes in the case of avian malaria). Steadman et al. (1990) found no hematozoa among blood smears from 79 native and introduced birds from the Cook Islands. While this absence would seem to be good news from a conservation standpoint, it may also indicate that native species of birds would have little resistance to blood-borne parasites should they be introduced to the islands. Atolls of the northern Cook Islands lacked mosquitoes in pre-European times (Gill 1885:199–200). Whether this was also true in the southern Cook Islands and elsewhere in Eastern Polynesia remains unknown.

Yet another subject for additional research and monitoring concerns the forests themselves. Most of the endangered species of Polynesian landbirds require forested or partly forested habitats, which continue to face threats from logging and the encroachment of nonnative species. Detailed descriptions and analyses of Polynesian forest vegetation, such as those of Stoddart (1975a), Merlin (1985, 1991), and Franklin and Merlin (1992), do not exist for most islands. The ecology of dispersal and pollination is virtually unknown for many species of Polynesian forest trees. I cannot imagine, however, that there have not already been serious long-term impacts on the dispersal and reproduction of forest trees caused by the loss of hundreds of populations of frugivorous, granivorous, and nectarivorous forest birds, such as megapodes, pigeons, doves, parrots, thrushes, starlings, and honeyeaters. Thus the loss of birds has undoubtedly had a negative effect on forests, which in turn has had a negative impact on the human populations that have depended on the forests for food, medicine, and building materials.

Flying foxes or fruit bats (Chiroptera: Pteropodidae) are also important pollinators and seed dispersers in the South Pacific (Cox et al. 1991; Fujita and Tuttle 1991). Like birds, flying foxes were hunted and eaten prehistorically, reducing their numbers and range (Steadman and Kirch 1990; Steadman 1991b; Koopman and Steadman 1995). These large bats continue to be popular food throughout much of the Pacific, resulting in dramatic further declines in recent decades (Wiles and Payne 1986; Wiles et al. 1989).

THE IMPACT OF BIRDS ON HUMANS

Prehistoric Polynesians had a major and negative impact on native birds. In this the Polynesians were not unique; I am aware of no group of humans, past or

present, rich or poor, Westernized or traditional, that has not reduced populations of birds and other animals, mainly through habitat alteration and hunting.

We already know that, on island after island, bones from archaeological sites indicate that indigenous species of both seabirds and landbirds were extirpated within the first millennium of human occupation. And, as the various native birds became rare or extinct, the nonfish vertebrate diet of Polynesians depended more and more on domesticated and commensal species (chickens, dogs, pigs, and rats). Here, however, I want to explore the reciprocal relationship: What sort of impact, aside from the obvious one of providing food, did native birds have on the lives of prehistoric Polynesians? As we shall see, Polynesians were interested in birds for many reasons other than as food. Because the Polynesian ethnobiology of birds is such an extensive subject, my coverage cannot be comprehensive. Rather, for each category, I shall provide a few examples and some discussion.

Nothing is as effective as extinction to decrease the interest in, and uses for, a species of bird. For each of the categories to be discussed, the process of avifaunal depletion that followed the human colonization of an island continually narrowed the range of species that people could use, whether as navigational or fishing aids, in legends and imagery, for their feathers or bones, or as pets. Thus the importance of birds in Polynesian societies, which was substantial at European contact, must have been even much greater before many of the species were lost.

Human Colonization

The dispersal and colonization of humans in what now is known as Polynesia began about 3,500 years ago, when a pottery-making people characterized as "the Lapita cultural complex" arrived in Western Polynesia after a rapid migration through Melanesia (see various chapters in Kirch and Hunt, eds., 1988). Although the record of birds exploited by the Lapita people is incomplete, evidence from Mussau, New Caledonia, Tikopia, Anuta, Fiji, Tonga, Futuna, and Samoa indicate that a wide range of seabirds and landbirds were taken and that many species did not survive the first millennium of human occupation (Balouet and Olson 1987, 1989; Steadman 1989a, 1989b, 1993a, 1993b and 1995; Steadman, Pahlavan, and Kirch 1990).

In spite of uncertainties about the chronology and spatial pattern of human colonization in Eastern Polynesia (Kirch 1986), there is a consistent pattern of heavy exploitation of native birds early in the cultural sequence (which begins up to 2000 B.P.), followed by an increased dependence on domesticated and commensal species (Dye and Steadman 1990).

Because birds provided such an important and easily available source of protein to early human colonists throughout Polynesia, the seemingly intense search for undiscovered, pristine islands may have been stimulated, at least in part, by the abundance of tame birds that greeted the discoverers of each new island. Thus the pursuit of unexploited avifaunas may have been a factor in the remarkable rapidity with which early voyagers colonized much of the Pacific. The tameness of Polynesian birds at first human contact must have been remarkable, the various species having evolved in ecosystems free of mammalian predators. Obtaining birds in the first centuries of human occupation may have resembled our concept of gathering more than hunting.

The extinction and extirpation of birds in Polynesia are reminiscent of some aspects of the blitzkrieg model of vertebrate extinction (Mosimann and Martin 1975; Martin 1984, 1990): a rapidly dispersing people who hunted intensively wherever they went, wiped out many species, and then moved on to richer hunting grounds. Not everyone, of course, moved on. Polynesians had a rich and productive set of domesticated plants and animals; on many islands, some portion of the founding populations seems to have remained to establish a more agriculturally based economy.

Navigation and Fishing

Seabirds were involved in traditional methods of navigation in Oceania. An important aspect of detecting nearness to an island was to keep an eye out for certain seabirds that seldom stray more than 20 to 100 km from the islands where they roost at night (Heyen 1963:71; Hilder 1963:90; Dening 1963:114–16; Lewis 1964:364; Sharp 1964:40; Gladwin 1970:180, 181, 188, 195–200; Lewis 1972:162–73; Finney 1979:334). Useful in this regard were boobies (*Sula* spp.), the Blue-gray Noddy (*Procelsterna cerulea*), and especially Brown and Black Noddies (*Anous stolidus, A. minutus*) and the Common Fairy Tern (*Gygis candida, = G. alba*). Tropicbirds (*Phaethon* spp.), frigatebirds (*Fregata* spp.), and Sooty Terns (*Sterna fuscata*) also were helpful, although their wandering habits made them fallible as indicators of nearness to land. In addition to true seabirds, the melodic two-note whistle of a migrant shorebird, the Lesser Golden-Plover (*Pluvialis dominica*), could be heard both day and night, and indicated nearness of land.

Observing birds also assisted fishermen in finding fish. In the Caroline Islands, Gladwin (1970:30) described how nearshore surface feeding by noddies and fairy terns would trap "the little fish in their frenzy between enemies above and below. It is the birds which signal to the fishermen that the [larger] fish are running in a school. All the canoes turn and plunge toward the birds." On Mangaia, by contrast, fishermen today say that the *kakaia* (Common Fairy Tern) is a trustworthy bird whose feeding activities often reveal productive

fishing grounds, whereas the *ngoio* (Brown Noddy) is a "cunning" bird that often will lead fishermen to sterile waters.

Inhabited islands tend to have far fewer seabirds than do uninhabited islands. Dening (1963:114) noted that "birds in great numbers became accepted in the Pacific by the explorers as the sign of an uninhabited island. In this we might find an explanation of why almost every uninhabited island in the Pacific gives signs of having been visited by the Polynesians. Lost voyagers would be easily attracted by the sign of birds." Fortunately for returning seafarers, noddies and fairy terns have been more resistant to over-exploitation than have other seabirds and thus have retained their usefulness in locating home islands in areas where sailing and deep-water fishing still occur.

The loss, however, of most other species of seabirds on most islands must have diminished the importance of seabirds as both navigational and fishing aids for prehistoric sailors. With few exceptions, the populations of shearwaters and petrels have been eliminated or depleted throughout Oceania. Especially out of the nesting season, most species of shearwaters and petrels are highly pelagic. The former role of these and other pelagic seabirds in blue-water navigation is uncertain (Hilder 1963:83, 84; Sharp 1964:42, 43, 47), although their feeding activities far offshore probably aided fishermen in locating pelagic species of fish and marine mammals. While I agree with Lewis (1972:172, 173) that the role of migratory landbirds in facilitating prehistoric long-distance voyaging is speculative and subject to criticism, those (like Sharp 1964:59, 61) who doubt the potential utility of pelagic seabirds in long ocean voyages should bear in mind that a respectable understanding of this matter is impossible today because: (1) seabirds are so drastically reduced in range and numbers (the total number of resident seabirds in the tropical Pacific today may be 100 to 1,000 times less than it was 3,000 years ago); and (2) the persons who study Polynesian navigation nowadays almost certainly do not understand the habits and field identification of Pacific seabirds as well as prehistoric sailors did.

Related to this is the possible role of seabirds as food to help sustain early Polynesian voyagers. Before their population declines occurred, seabirds may have been a significant food supplement, although methods of luring them at sea near enough to be captured are unrecorded. Ethnographic accounts of long-distance voyaging virtually lack mention of taking seabirds at sea; the only reports I have found are of a group of native missionaries from Aitutaki who killed a "few sea-birds" during five months at sea in the 1820s (Dening 1963:138) and of several Great Frigatebirds (*Fregata minor*) caught after landing in the rigging of a ship off Nassau in the Cook Islands in the mid-1800s (Gill 1885:31).

Feathers

Items made of feathers occurred throughout Polynesia. Although cloaks, headdresses, skirts, and fans are especially well known, feathers adorned many other items, such as wooden and tapa images and the tails of kites (Buck 1944:80–102, 258, 311, 318, 320, 327, 332–36, 345–47, etc.). The color red was associated with major deities, such as Tangaroa in the Cook Islands (Buck 1934:16) and Oro in the Marquesas, Tahiti, and Tonga (Parsonson 1963:29). Thus red feathers, when available, were particularly important and valuable. Red feathers were sometimes used to decorate canoes (Gill 1894:134). In the Cook Islands, the word *kura* was used variously to mean "red," "feather headdress," or "parrot." I believe that the parrot signified by kura is *Vini kuhlii* (the Rimatara Lorikeet), a predominantly red species that survives on Rimatara in the Austral Islands but has been found in archaeological contexts on Aitutaki, Atiu, and Mangaia and seems to have occurred into early historic times on Palmerston, Manuae, and Rarotonga. Words ranging from priceless and precious to sacred and beautiful were used to describe red parakeet feathers in Mangaian stories. After the Rimatara Lorikeet had been lost on Mangaia, its treasured feathers were imported in late prehistory (Gill 1894:235, 240–42, 255).

Although they are known only from bones, it is likely that the larger extinct parrots of Eastern Polynesia (*Vini vidivici* of the Marquesas, Society, and Cook Islands, and *V. sinotoi* of the Marquesas and Society Islands) also had significant amounts of red in their plumage. There is ethnographic evidence that red feathers were brought to Mangaia from as far away as Tahiti, where no red parrot exists today. (The Black-fronted Parakeet, *Cyanoramphus zealandicus*, and Raiatea Parakeet, *C. ulietanus*, which survived into the early or mid-nineteenth century in the Society Islands, had only minor amounts of red in their predominantly brown-and-green plumages.) In describing a late prehistoric conflict, Buck (1934:131) stated: "The father [Rongo-ariki], after handing his son [Rori] some precious red feathers from Tahiti, stayed behind to delay the enemy and so make good his son's escape." Ironically, Rori's own three sons were later killed in battle while wearing red feather headdresses (Buck 1934:206).

With the loss of red parrots virtually throughout Eastern Polynesia, the two long central tail feathers of the Red-tailed Tropicbird (*Phaethon rubricauda*) became the primary source of red feathers. Pursuit of these tail feathers took Polynesians to uninhabited islands, sometimes hundreds of kilometers from home. In the Fiji-Tonga-Samoa-Niue region, four species of parrots with red in their plumage survived into historic times in spite of human-caused range contractions. These species are the Red-throated Lorikeet (*Charmosyna*

amabilis), Collared Lory (*Vini [Phigys] solitarius*), Blue-crowned Lorikeet (*V. australis*), and Red Shining-Parrot (*Prosopeia tabuensis*). A large extinct parrot, *Eclectus* new sp., was exterminated prehistorically on 'Eua (Steadman 1993a). Based upon the bright red plumage in the females of its only surviving close relative, the Eclectus Parrot (*E. roratus*) of Western Melanesia, it is probable that the extinct species of *Eclectus* from 'Eua was yet another source of red feathers for early Tongans.

Although red may have been preferred throughout Polynesia, feathers of virtually any other color were also used. Prehistoric Niueans wore girdles that included white, yellow, and green as well as red feathers of *V. australis* (Loeb 1926:93, 163). Gill (1894:26, 27) reported a cloak from Mangaia made of "the beautiful white, green, blue, and yellow feathers of the birds they had eaten." Feathers of frigatebirds and pigeons (*Ducula* spp.) were used on many islands. Chicken feathers were used for a variety of headdresses and other ornaments on Easter Island (Metraux 1940:220–28). The choice of chickens was an obvious one, as all native landbirds and most seabirds had been wiped out prehistorically on Easter Island itself. Certain seabirds could be obtained seasonally on two offshore islets, and F. E. Eyraud described "a sea bird whose carcass had been opened more or less carefully" and used as a headdress by an Easter Islander in 1866–67 (Metraux 1940:220).

Bones

Being light and hollow but very strong, bird bones were important raw materials for tools, toys, and ornaments. Because bones are readily preserved in archaeological contexts, our knowledge of them, unlike our knowledge of feathers, covers the entire period of prehistory.

Sewing needles were made of the ulna or, more often, the radius, by cutting one end perpendicular to the long axis, drilling a small hole in the shaft near the cut end, and filing the other end to a hollow point. This type of needle is commonly found in prehistoric contexts on Easter Island (Metraux 1940:213; Heyerdahl 1961:412), where it is called *ivi tia nua*. At Ahu Naunau, Anakena, Easter Island, two such needles were recovered in July 1991 from sediments dated to about 700–800 B.P. (Steadman, Vargas, and Cristino 1994). These needles had been made from the radii of Murphy's Petrel (*Pterodroma ultima*), a tropical seabird that no longer occurs on Easter Island.

Tattooing needles were made of bird bone on Easter Island (skeletal element and species unrecorded; Metraux 1940:237'38, 241), the Cook Islands (details unrecorded; Buck 1944:128), and Tikopia (humerus, ulna, and radius of frigatebirds; Steadman, Pahlavan, and Kirch 1990:147). Mammal bones also were used as tattooing needles in many places.

Whistles were made most often from the thin-walled bones of large seabirds, such as frigatebirds or boobies. From 'Anatu on 'Eua, I have excavated a still functional whistle (length 48 mm) made from the radius of a Lesser Frigatebird (*Fregata ariel*). From Hanatekua Shelter No. 2 site (MH-11) on Hiva Oa in the Marquesas, I have identified the cut proximal 44 cm of another radius of *F. ariel*. Presumably, the adjoining piece (not recovered) would have been the whistle. Certain skeletal elements of chickens and large native birds, especially the humerus, ulna, and tibiotarsus, were cut in short sections to serve as beads. From Tangatatau Rockshelter on Mangaia, P. V. Kirch and I recovered in 1991 the entire sternum of a chicken in which two holes had been drilled. This probable pendant came from strata dated to about 600 B.P.

Names, Imagery, and Legends

These three subcategories are too intertwined to separate clearly. Polynesian names for birds are significant from both a linguistic (Clark 1982) and an ornithological (Steadman 1985) standpoint. Many avian names reappear as cognates throughout much or all of Polynesia. One of many such examples is the proto-Polynesian *matuku* (variations include *matu'u, motuku, kotuku,* and others; Clark 1982), which refers to the widespread Pacific Reef-Heron (*Egretta sacra*). Occasionally, some rather drastic name changes reflect local onomatopoetic interpretations, such as *tanga'eo* for the Mangaia Kingfisher rather than *ngotare* or *kotare,* used for closely related Eastern Polynesian species. Other major name changes are difficult to explain, such as *iwa* for frigatebirds in Hawaii rather than the widespread name *kota'a* and its cognates.

In some areas of Polynesia, one can find names of birds in dictionaries that refer to species that no longer exist on a particular island. Such names generally have fallen into disuse. Dictionaries for Rarotonga (Savage 1980, actually compiled between about 1900 to 1940) and Tahiti (Andrews and Andrews 1944) are rich sources of such names. To mention only two examples, Savage (1980:117, 122) lists Rarotongan words that indicate the former presence there of a kingfisher (*kotare;* presumably the Chattering Kingfisher, *Halcyon tuta,* or closely related species) and a small red parrot (*kura;* presumably the Rimatara Lorikeet).

Bones from archaeological sites can corroborate the former existence of birds otherwise known only from stories or linguistic evidence. Clark (1982) deduced that a bird similar to the Purple Swamphen (*Porphyrio porphyrio,* proto-Polynesian name *kalae*) must have existed in the Marquesas or Society Islands, the presumed source areas of Hawaiian people, because the Hawaiian cognate *'alae* refers to similar large rails (Common Gallinule, or Moorhen, *Gallinula chloropus,* and American Coot, *Fulica americana*). No rails in the

genera *Porphyrio, Gallinula,* and *Fulica,* however, had ever been found in Eastern Polynesia (Holyoak and Thibault 1984), the nearest occurrence being that of *P. porphyrio* in Tonga, Samoa, and Niue (Pratt et al. 1987). Raynal (1980–1981) noted that the Marquesan name *koau* refers to a flightless bird, with bluish purple plumage and yellow bill and feet, that existed earlier this century on Hiva Oa. Raynal proposed that the *koau* was related to the flightless swamphen of New Zealand, known as the *takahe* (*Porphyrio mantelli*). In 1986 and 1987, while examining bones from archaeological sites on Hiva Oa and Tahuata, I discovered 19 specimens that belonged to an undescribed species of swamphen, subsequently named *Porphyrio paepae* (Steadman 1988). While this adds support to the proposals of Clark (1982) and Raynal (1980–1981), it does not solve the linguistic discrepancy between *kalae* and *koau.* The bones from Hiva Oa are all more than 1,000 years old, while those from Tahuata are at least 700 to 800 years old. Raynal and Dethier (1990) have suggested that a "cryptozoological" search be made on Hiva Oa to see if *P. paepae* still exists.

A somewhat similar situation involves megapodes (*Megapodius* spp.). Clark (1982) pointed out that cognates of the Tongan and proto-Polynesian word for megapode, *malau,* are found in various places in Melanesia and Indonesia. Because megapodes are lacking in Fiji, through which proto-Polynesian speakers must have traveled on their way to Tonga, use of the word *malau* in Tonga suggests that megapodes must have existed at one time in Fiji. (In Tonga today, a single species of megapode, *M. pritchardii,* is confined to Niuafo'ou.) Archaeological bones have now shown that megapodes did exist two or three millennia ago not only in Fiji but also on Ofu (American Samoa) and on Lifuka and 'Eua in Tonga (Steadman 1989b, 1993a, 1993b). The most thorough record is in Tonga, where four species, three of them extinct (°), have been recorded (°*M. molistructor,* °*M. alimentum,* and *M. pritchardii* on Lifuka and Foa, °*M. alimentum, M. pritchardii,* and °*M.* new sp. on 'Eua). As megapodes became increasingly localized in the Fiji-Tonga-Samoa region, their eggs became one of the prestigious trade items of a well-organized long-distance exchange network (Steadman 1991c; see Dening 1963 and Kirch 1984:238–42, 1988:257–60 for details of this network).

Clark (1982) also used cognates of the proto-Polynesian *lulu* (Common Barn Owl, *Tyto alba*) to propose that some sort of owl once existed in Eastern Polynesia. This suggestion has not been substantiated by bones. Lastly, Clark (1982) interpreted cognates of the proto-Polynesian *siwili* and *kula* to suggest that a larger parrot once existed in Fiji or Tonga, a suggestion now supported by discovery on 'Eua of the large extinct parrot, *Eclectus* new sp. (Steadman 1993a).

The Polynesian names of birds were sometimes used to name other things. Te Ana o Kakaia (the Cave of the Fairy Tern) is a large cave in the Ivirua district of Mangaia that served as a place of refuge for Ruanae and his clan after they were defeated in a battle said to have occurred in 1718 (Gill 1885:74, 1894:167). True to the cave's name, each of the six bird bones I recovered from Te Ana Kakaia in 1984 were those of the *kakaia* (*Gygis candida*). The lack of bones from extinct or extirpated species suggests that the cave was inhabited only late in prehistory.

Two other well-known Polynesian caves have names involving birds. Ana Taketake (var. Ana Takitaki) on Atiu is named after the sound made by echolocating Atiu Swiftlets (*Collocalia sawtelli;* Holyoak 1974, 1980; Holyoak and Thibault 1978; Steadman 1991b). Ana Kena on Easter Island is named after the Masked Booby (*Sula dactylatra*). Ana Kena, originally the name of a cave only, has been merged into the single word *Anakena* to refer to the surrounding region, which consists of a valley mouth and protected bay, a site of much archaeological and paleoecological importance (Kirch, Christensen, and Steadman n.d.; Steadman, Vargas, and Cristino 1994).

Two vanquished leaders in Mangaian prehistory were named after birds (Buck 1934:35): Mokora (Gray Duck, *Anas superciliosa*) and Kota'a (frigatebird; Polynesians seldom distinguish between the two local species, *F. minor* and *F. ariel*). The bird's nest fern (*Asplenium nidus*) of Cook Island forests is called *rau kota'a* (Gill 1894:224) or, more often today, simply *kota'a* (Wilder 1931:9; pers. observation), in reference to its leaves, which resemble in shape the long, narrow wings of frigatebirds. The graceful kites once made in the Cook Islands were called *manu tukutuku* ("letting go a bird"), *manu—aka-rere* ("flying bird"), or simply *manu* ("bird"; Buck 1944:257; Savage 1980:139).

The words *rupe* and *lupe* refer to the Pacific Imperial-Pigeon in the Cook Islands and Western Polynesia, respectively. On Mangaia, where no species of pigeons survive, there is a valley named *rupetau* (Gill 1894:209). *Tau* means "to alight, to come to rest" (Savage 1980:363), thus *rupetau* seems to be named after a former pigeon roost.

All sorts of birds were involved in Polynesian stories and sayings, which often were based in part on the habits of a bird. On Niue, for example, many *pekapeka* (White-rumped Swiftlets, *Collocalia spodiopygia*) were said to leave their caves and "dance" in the sky before a rain (Loeb 1926:179). Thus the swiftlets' period of heavy aerial feeding on insects helped Niueans to predict rain. Although Polynesian stories often reveal an appreciation and understanding of birds, they indicate a "close harmony with the natural world" (as purported by Muse and Muse 1982:ix) only if such harmony includes preda-

tor-prey relationships. Many Polynesian stories include or imply the death of the bird, particularly if it is a highly edible species, such as a shearwater or pigeon.

Birds were often associated with Polynesian deities. Such an association may have been accompanied by a taboo on killing that particular species. The fact that bones of "deified" species are frequently recovered in archaeological sites may reflect local or chronological differences in their protective status. For example, a common migratory shorebird, the Lesser Golden-Plover, is regarded as sacred by modern Tikopia, who also associate with deities the resident Pacific Imperial-Pigeon and migratory Long-tailed Cuckoo (*Eudynamis taitensis*). Bones of all three species were found on Tikopia in archaeological contexts (Steadman, Pahlavan, and Kirch 1990).

The endemic Mangaian Reed-Warbler (*Acrocephalus kerearako*), onomatopoeically called *kerearako* on Mangaia, was regarded as the incarnation of the god Tane (Buck 1934:163, 171). The Bristle-thighed Curlew (*Numenius tahitiensis*) is a large migratory shorebird variously called *kiu* or *kau'a,* again because of its melodic voice. Prehistoric Mangaians regarded both the curlew and warbler as "mouthpieces" of the god Tane (Gill 1885:116–17, 1894:332; Buck 1934:172). The *kau'a* was "considered to be good eating by the natives, the tribe of Tane excepted" (Gill 1885:117). Another vocal bird, the Mangaia Kingfisher, or *tanga'eo,* was associated with the gods Utakea and Tekura'aki (Buck 1934:166, 171).

According to legend, a Pacific Imperial-Pigeon belonging to the god Tangaroa mated with "a female shadow of great beauty" and became the father of the first man on Atiu (Gill 1894:262–63). On Mangaia, the god Motoro was "proudly called *te io ora* = 'living-god,' as his worshippers were *not* eligible for sacrifice" (Gill 1894:332). Motoro was represented in sennit work and carvings from the *oronga* (a small tree, *Pipturus argenteus*), which used the *mo'o* or *mo'o mo'o* (Sooty Crake, *Porzana tabuensis*) as his incarnation (Buck 1934:166, 171). Association of the mo'o mo'o with life may have been because this bird inhabits taro swamps, which for centuries have been of utmost important to Mangaian subsistence.

Easter Island is well known for wooden carvings and petroglyphs of stylized birds and birdmen, the latter consisting of the head of a bird (often the Great Frigatebird) attached to a human body (Metraux 1940:256–59, 270–72; Lee 1986). Bird glyphs also appear in the famous *rongorongo* wooden tablets of Easter Island (Metraux 1940:389–411). The "bird cult" of Easter Island involves the small population of Sooty Terns that nests opposite Orongo on the offshore islet of Motu Nui (Metraux 1940:331–41). This cult may have increased in religious significance late in prehistory because of the rarity (and therefore value) of seabirds and their eggs. The seabirds and landbirds on Easter Island itself had already been exterminated.

Birds also appeared in Polynesian riddles, such as "Who with a black skin is ever clothed in purest white? A species of tern [Common Fairy Tern], common in the Pacific" (Gill 1885:268). Following the arrival of missionaries in the nineteenth century, birds continued to have roles in stories that were Christianized (Gill 1885:92, 108, 110, 136–37; 1894:372–73).

Pets

Polynesians enjoy keeping birds as pets, a habit that may be decreasing in popularity. Generally the birds are obtained as nestlings and are hand-reared, increasing their tameness. On Mangaia I have seen a Brown Noddy (obtained locally) and a Red-footed Booby (*Sula sula,* obtained on Penrhyn) kept as tame pets in sheds behind houses. The noddy is also sometimes kept on Tikopia. Frigatebirds were kept as pets in Samoa (Armstrong 1932:17) and Tuvalu (Gill 1885:17–18), as were White-tailed Tropicbirds (*Phaethon lepturus*) in Tonga (Lewis 1972:169). The Pacific Imperial-Pigeon and Crimson-crowned Fruit-Dove were commonly kept in Samoa (Armstrong 1932:1, 58). The Red Shining-Parrot is indigenous to Fiji (Layard 1876; Rinke 1989) but was kept as a pet in Samoa (Armstrong 1932:91) and still is held captive (and exported?) on 'Eua, Tonga (pers. observation). The Tahiti Lorikeet (*Vini peruviana*) was noted in captivity on Aitutaki (Townsend and Wetmore 1919).

CONCLUSION

It is not surprising that birds were extremely important to early Polynesians, who arrived on one pristine island after another, each inhabited by a variety of birds but few if any species of reptiles or mammals. The importance of birds, however, did not save them. The net effect of the human occupation of Polynesia has been the elimination of much of the original bird life. Also gone is most of the natural habitat that supports those species of birds that have survived.

We know from archaeological sites that birds were killed and consumed regularly by early Polynesians. Nevertheless, it is difficult from this evidence to assess the relative contribution to avian extinction from direct human predation versus other prehistoric anthropogenic factors, such as habitat loss, disease, or predation from rats, dogs, and pigs. The importance of each factor probably varied from island to island. Regardless of the specifics of any individual case, human presence on tropical islands has been called an environmental catastrophe (Olson 1989). Although this statement may be contro-

versial from an anthropological standpoint, you would find few birds that would argue against it. I say this without judgment; I am not criticizing any individual person, living or deceased, who has killed birds (I have killed some myself, in the name of science) or who has destroyed forest (which we all do, at least indirectly, for food, lumber, paper, and so forth).

I have mentioned some of the conservation programs that have been or could be undertaken to improve the lot of Polynesian birds. Although conservation agencies can perhaps save more species per dollar on the mainland tropics than on islands, there is something undeniably special about islands and their unique biotas. Programs to conserve Polynesian birds should be considered for the sake of the birds themselves, not to mention preserving an important part of the human heritage of Polynesia. These programs are important for the future of science as well. It is no coincidence that Charles Darwin and Alfred Russel Wallace came up with many of their most brilliant insights while studying island faunas, as did other great names of zoology, such as Ernst Mayr, David Lack, Robert MacArthur, Edward Wilson, and Jared Diamond. In anthropology, such prominent figures as Bronislaw Malinowski, Margaret Mead, Sir Raymond Firth, and Marshall Sahlins were inspired to new heights of creativity through studies of island peoples.

Any attempts to preserve the remaining fragments of Polynesian bird life must consider the importance of involving local people (Hay 1986). Interest in nature seems to be waning as cash economies replace subsistence agriculture. If environmental protection is to succeed in Polynesia, this interest in nature must be kept alive in young Polynesians as they inherit their island environments. More than 50 years ago, Aldo Leopold wrote: "Conservationists have, I fear, adopted the pedagogical method of the prophets; we mutter darkly about impending doom if people don't mend their ways. The doom is impending, all right; no one can be an ecologist, even an amateur one, without seeing it. But do people mend their ways for fear of calamity? I doubt it. They are more likely to do it out of pure curiosity and interest" (1991:99, 101). In the next few decades it will be fascinating to participate in the interplay of science, culture, economy, and environment in the South Pacific.

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