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Man, Moa and the Forest

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Abstract

IN this paper, information from botanical, zoological, geological and archaeological sources has been brought together in order to suggest the inter-relationships of man, the forest and the moa. It is essentially a review of available information in an attempt to understand the changing ecological situation of pre-historic man in New Zealand.

IN 1953, C. A. Fleming wrote that " extinction of the moas (and their companions) is the most outstanding faunal change of the Recent Period of New Zealand " (Fleming, 1953: 118). The moa and many of the other birds had survived the Ross, Waimaungan and Otiran glaciations of the Pleistocene. According to the generally accepted theory of moa ecology, these birds belonged to the open tussock areas. If this were so, then the almost tundra conditions during and following the Otiran glaciation should have suited them far better than the previous and subsequent forest-covered landscape. If the moa belonged to an established grass-land habitat, then one would expect to find other open country birds associated with them, but these are relatively rare (Oliver, 1955).

The earliest record of the moa is from Maungapurua, Upper Wanganui, where it occurs in an approximate Upper Kapitean (uppermost Miocene) horizon (Fleming, 1962b: 81). The moas were probably present as early as the Upper Cretaceous (Fleming, 1962a: 272). Climate at this time was probably moist warm temperate (Fleming, 1962b: 66) and shows the rise of *Angiosperm* plants. Oliver (1950: 6), in discussing the fossil pollen of Shag Point in Otago, specifically refers to *Araucariaceae* and *Podocarpaceae,* the former including *Agathis lanceolatus*, a kauri-type tree. Oliver likens the flora to that of the mid-mountain zone of New Guinea (Oliver, 1950: 6). During the late Cretaceous, the land connections which may have existed beyond New Caledonia deteriorated and were not again possible until the Miocene (Fleming, 1962b: 105). By the uppermost Miocene the earliest moa fossil is identifiable as *Pachyornis mappini* (Oliver, 1949: 65), indicating that diversification and speciation had already taken place and suggesting strongly that the postulated Cretaceous immigration of the moa genera could be correct. The diversification of the moa could have been due to the " changing archipelagic stage in New Zealand history during the Tertiary epoch " (Fleming, 1962b: 68). The Paleocene–Eocene periods had a warm tropical climate with many forest plants dominated by the Cretaceous podocarps (Fleming, 1962b: 70), with new arrivals including *Nothofagus* of the *fusca* groups which tended to replace the podocarps

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in the later stages. The Oligocene was also noted for its sub-tropical forests dominated by *Nothofagus* of the *brassi* groups (Fleming, 1962b: 75). Conifers were rare, but at Ohai in Southland, Oliver records the appearance of *Araucaria* or *Agathis* types (Oliver, 1950: 8). The conifers and *Nothofagus* at this time could be an indication of a more open habitat situation in a drier climate (Fleming, 1962b: 75). The known Miocene plant cover continues the *Nothofagus brassi* group dominance with introductions probably correlated with an increasing rainfall (Fleming, 1962b: 78). During the later Middle and Upper Miocene, the *fusca* group of *Nothofagus,* podocarps and ferns increased, suggesting increased rainfall, but in turn many of the warmth-loving species of molluscs and plants became extinct at the end of the period (Fleming, 1962b: 81). While the climate was cooler in the succeeding Pliocene, *Nothofagus* of the *brassi* group was dominant as far south as Dunedin and *Agathis* (Kauri) was locally common (Fleming, 1962b: 84). The Early Pleistocene flora and fauna show progressive evidence of a cooling climate and the effects of the glaciations. The implications of this will be discussed in more detail further on.

This information, fragmentary as it is, could suggest that a fairly good forest cover was present in many areas up till the Pleistocene. A working hypothesis could then be formulated that during the initial phases of moa establishment, colonisation and subsequent phylogenetic diversification, the moa were associated with forested areas or at least partly forested areas. To support this is the evidence of the geologically recent swamp deposits in which gizzard contents have been preserved, to indicate that the moa, including the largest *Dinornis,* were intimately associated at that time with mature forest stands from which much of their food was obtained (Oliver, 1949: 81). As it is likely that the moa at the earlier stages of their history, at the time of the earliest known moa fossils and in recent deposits, were forest or forest fringe birds, it may be postulated that in the intervening periods they were also associated with forest. An interesting correlation emerges from the brief summary of plant history in New Zealand. Pollen of the *Nothofagus brassi* group first appears in the lowest Paparoan Beds of the Cretaceous (Fleming, 1962b: 66). Trees of this type now survive only in the uplands of New Caledonia and New Guinea (Fleming, 1962b: 72). A present-day inhabitant of the New Guinea rain forest is the cassowary (*Casuarius*) and as Oliver remarks: "The group nearest related to the moas and kiwis is that of the emus and cassowaries" (Oliver, 1949: 183). While this relationship is rather distant, it is perhaps significant that the spread of *Nothofagus brassi* and possibly podocarps corresponds with the postulated advent of the moa and that in the region where the plant form survives, the cassowaries should be dwelling in the rain forest finding their food in seeds of palms knocked down by pigeons, fruits, berries, insects and plant tissues (Keast, 1964: 123).

There seems to be fairly general agreement that the Otiran glaciation, which ended about 10,000 years ago, produced periglacial conditions over vast areas of the South Island and Central North Island (Wardle, 1963: 9). A restriction of the forest area rather than a complete disappearance of all trees during the glaciation is more likely. The New Zealand flora contains numerous forest species, but only a handful of open country species (Wardle, 1963a: 8). Wardle has noted that the weak development of open lowland forms as compared with the richness of the forest plants would indicate that there were only brief periods when the climate was suitable for the development of open country plants. Many of the forest species of trees have long histories in the fossil record (Oliver, 1950; 10; Fleming, 1962b: 101) or are derived from long-established forms which have persisted despite marked changes in land form, sea level and climate. Wardle postulated on the basis of the numbers of pre-glaciation forms surviving, that during the Otiran glaciation there were refugia in Otago–Southland, Nelson–Marlborough and the northern part of the North Island. It would seem that only the mid-South Island and the southern North Island suffered marked local extinction during the glaciations (Wardle, 1963a: 13). After the end of the last glacial period, some ten thousand years ago, colonisation and plant succession would have been active. Just when this took place is not certain, but the pollen record indicates that there was only a short period following the Otiran glaciation when abundant tree pollens were not present in most areas (Speight, 1911: 166; Cranwell and Van Post, 1936: 375; Harris, 1955: 287; Molloy, 1964: 166).

It is suggested that the moa, definitely known as early as the Kapitean, was able to survive the glaciations by feeding on forest plants in the refugia. The moa, if then dependent on the forest, would be greatly restricted in distribution and the population drastically decreased in numbers. The various species might then emerge from the last glaciation with a much impoverished gene pool. Subsequent extension of the forest, while supplying the food for increasing population numbers, would not materially affect the genetic situation. The suggested gene impoverishment would mainly affect the fertility rate as it probably has in the case of the takahe (Williams, 1960: 254); but could also be evident in other ways, for example, Archey, in discussing what he regards as contemporary moa populations refers to the great variation and haphazardness in skeletal features (Archey, 1941: 98). Oliver, in referring to causes of extinction, says, " The moa came to be a misfit as a result of an unvarying evolutionary history and was quite ready to succumb to a change in the environment (Oliver, 1949: 194). Simpson (1949: 204) lists three conditions which could lead to extinction of a group:

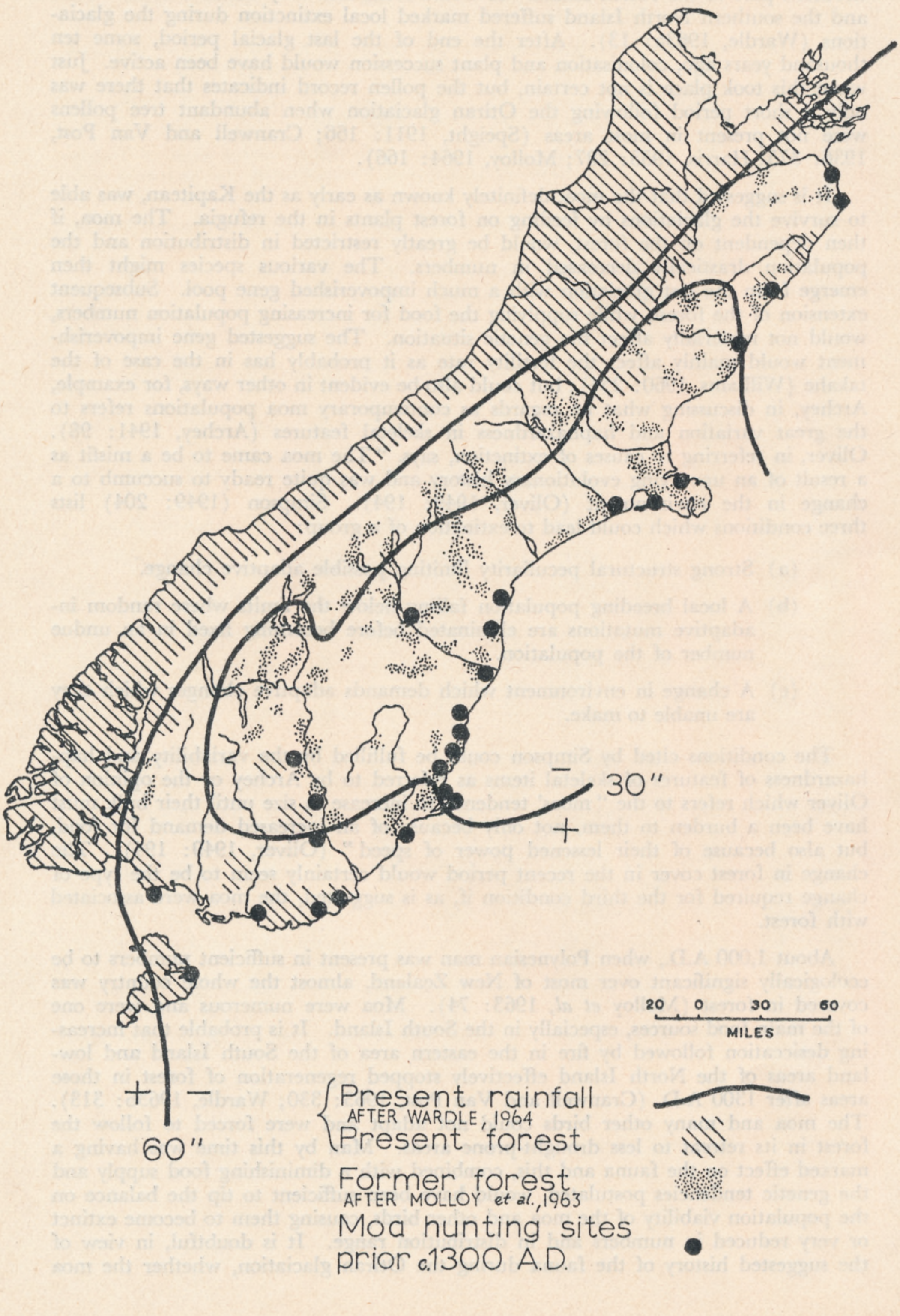
(a) Strong structural peculiarity limiting possible adaptive change.

(b) A local breeding population falling below the limits where random inadaptive mutations are eliminated before becoming fixed in an undue number of the population.

(c) A change in environment which demands adaptive changes which they are unable to make.

The conditions cited by Simpson could be fulfilled by the variability and haphazardness of features of skeletal items as referred to by Archey or the opinion of Oliver which refers to the " moas' tendency to increase in size until their bulk must have been a burden to them, not only because of an increased demand for food, but also because of their lessened power of speed " (Oliver, 1949: 194). The change in forest cover in the recent period would certainly seem to be the type of change required for the third condition if, as is suggested, the moa were associated with forest.

About 1,000 A.D., when Polynesian man was present in sufficient numbers to be ecologically significant over most of New Zealand, almost the whole country was covered in forest (Molloy *et al*, 1963: 74). Moa were numerous and were one of the main food sources, especially in the South Island. It is probable that increasing desiccation followed by fire in the eastern area of the South Island and lowland areas of the North Island effectively stopped regeneration of forest in those areas after 1300 A.D. (Cranwell and Van Post, 1963: 330; Wardle, 1963b: 313). The moa and many other birds could not adapt and were forced to follow the forest in its retreat to less drought-prone areas. Man by this time was having a marked effect on the fauna and this, combined with a diminishing food supply and the genetic tendencies postulated, would have been sufficient to tip the balance on the population viability of the moa and other birds, causing them to become extinct or very reduced in numbers and in distribution range. It is doubtful, in view of the suggested history of the fauna during the Otiran glaciation, whether the moa



30"
60"
20 0 30 60
MILES
Present rainfall
AFTER WARDLE, 1964
Present forest
Former forest
AFTER MOLLOY et al, 1963
Moa hunting sites
prior c.1300 A.D.

could have survived as a relic population even if man had not been present. Man undoubtedly hastened the extinction of the moa but deliberate extermination is not likely. It was probably not man alone, restriction of forest area or genetic tendencies, but a combination of all these factors which completed the extinction of the moa and the other birds.

The fact that quite a large section of the bird fauna was heading for extinction in the post-Pleistocene period is demonstrated by 40 species of birds becoming extinct in the prehistoric period. European contact, which has had a much greater effect on the ecology than any Polynesian practice, has resulted in only five species becoming extinct (Williams, 1962: 17). Fleming (1962c: 118) draws a parallel between the New Zealand extinctions and the extinction or reduction of large herbivorous vertebrates in European post-glacial times.

Natural deposits in which moa occur also contain much evidence of associated forest and forest birds. Pyramid Valley, near Waikari in Canterbury, is the best recorded of these natural deposits. A large number of moa bones have been found there belonging to six different species (Duff, 1955: 255). The majority of these are embedded in a yellow marl layer which lies between two widely separated layers of peat (Falla, 1941: 339–40; Eyles, 1955: 259–60). In two instances the moa were found to be protruding into the upper peat. It has been suggested that most of the birds were trapped after the formation of the upper peat and after the withdrawal of the forest in the area (Duff, 1963: 20). The gizzard contents of two of the moa so far recorded make this hypothesis unlikely. The gizzards belonged to a *Dinornis* sp., the largest of the moa, and a medium-sized *Emeus* and contained seeds of matai, ngaio, *Nertera, Carmichaelia, Gaimardia,* kamahi, a *Rubus* climber, an *Epilobium* herb, fruits of sedge, seeds of *Suttonia divaricata* (a shrub) and eared sundew (Falla, 1941: 341; Oliver, 1949: 181). Harris (1955: pl. 7) in the pollen profiles for the Pyramid Valley deposit, records a maximum of 66 percent *podocarpoid* pollen and 48 percent *Nothofagus* (beech) pollen in the yellow marl. There are some fluctuations, but pollen from either one of these two main trees never fell below 20 percent. Teatree was never greater than 10 percent and grass or bracken only came in with the covering peat after the forest pollens had fallen. The proportions of the various pollens in the yellow marl point to a mature forest stand (Mark *et al,* 1964: 71). It is likely that the lower and upper peats were both formed during periods of forest recession (Harris, 1955: 287) when the lake was dry enough to allow the formation of bog conditions. The pollen profiles at Pyramid Valley are remarkably similar to those recorded at Swampy Hill near Dunedin, and Mossburn in Southland (Cranwell and Van Post, 1936: 322–323, 336–337, 342, 343).

Recent radiocarbon dates (Gregg, 1967: 157–158) have confirmed the interpretation placed on the Pyramid Valley deposit. Specifically, leaves, twigs, and seeds in the yellow calcareous mud (or marl) have yielded the following dates:

68– 73cm	670 ± 49 B.C.
81– 86cm	980 ± 63 B.C.
116–123cm	1770 ± 60 B.C.

Moa gizzards from the same layer (also containing leaves, twigs and seeds) have been dated as follows:

Dinornis maximus	1690 ± 72 B.C.
Emeus crassus	1790 ± 72 B.C.
Eurapteryx gravis	1500 ± 71 B.C.

Collagen from the same *Emeus* individual was dated to 1650 ± 45 B.C. The top of the lower peat is dated to 2330 ± 62 B.C. It is probable that the upper peat coincides with the thirteenth to sixteenth century A.D. forest recession (Harris, 1955: 288), which is followed by grassland as in Otago and part of Southland (Cranwell and Van Post, 1936: 326).

The crop contents of the two moa indicate that they belong in the period when bush or bush fringe plants were available for their immediate needs. Other bird remains (Scarlett, 1955) from the yellow marl include, as extinct forms, the giant goose (*Chenopsis sumnerensis*), the eagle (*Harpagornis moorei*), the little woodhen (*Gallirallus minor*), the giant rail (*Aptornis otidiformis*), the coot (*Palaeolimnas chathamensis*), the crow (*Palaeocorax moriorum*), and Finsch's duck (*Euryansis finschi*). Species found which now have a very restricted range are the takahe, kokako (the wattled crow), the kakapo, the laughing owl, the saddleback and a small kaka. Waterfowl found, which were in 1840 still present in the Canterbury region, are the dabchick, paradise duck, grey teal, grey duck, brown teal, scaup and stilt. Bush birds still extant in other areas are, apart from those already mentioned, the falcon, weka, pigeon, kaka, red-fronted parakeet, morepork, New Zealand thrush, tit, robin, tui and kiwi. In all, out of a total list of 36 birds, other than moa, from Pyramid Valley, 12 are waterfowl or waders, two are open country birds, five are rails which prefer bush or bush fringes and 17 are bush birds (Oliver, 1955).

Pyramid Valley provides the most abundant and best documented swamp evidence for associating forest, forest birds and moa. Other swamp deposits such as Kapua (S. Cant.) (Hutton, 1896: 627–44), Te Aute (H.B.) (Oliver, 1949: 8–9) Poukawa (H.B.) (Price, 1963: 169–73), and Conoor (Oliver, 1949: 14–15) also contain forest trees or bones of forest birds associated with moa. Gizzard contents from Wanaka also include forest seeds, probably matai (Otago Museum). Cave deposits from Martinborough in the Wairarapa provide fairly conclusive information associating moa and the forest. Yaldwyn (Yaldwyn, 1958: 132–3) summarises his evidence as:

" For some time during the last 8,000 years, probably until only a few hundred years ago, the mixed podocarp-broadleaf forest of the Haurangi Mountains, Eastern Wairarapa, at about 2,500ft above sea-level, contained at least the following flying birds: New Zealand falcon, blue-wattled crow, robin, pigeon, kaka, parakeet, saddleback and tui. At the same time there was a large ground bird fauna, containing a number of extinct forms. There were several moas, representing three genera (*Anomalopteryx, Pachyornis,* and *Dinornis*), a kiwi, the extinct flightless duck (very common), a large rail (*Aptornis*), a large takahe, several wekas, and the kakapo (very common). While the list of ground birds can be regarded as fairly complete, it can be assumed that many more flying birds, unrepresented in the deposit were then present."

The ecological position of the moa as associated with forest is important in understanding the somewhat brief sojourn of man in these islands. The first Polynesian immigrants to this country had to adapt to a new ecological situation. In most areas of the country subtropical agriculture was found impractical or impossible and hunting was substituted. Birds were the most plentiful available source of food and the moa quickly became important in the economy. Information on the prehistoric economy is not complete, as unfortunately some of the important early sites were dug or destroyed before full details of midden bones were recorded. The range and numbers of moa and other birds utilised for food and raw material could be an indication of relative age as later sites contain fewer species and numbers. In some South Island sites in the nineteenth century moa bones were sufficiently numerous to be considered seriously as grist for the fertiliser mills.

Archaeological sites for which there is a part or complete record of all birds present include both early and late sites. For the purpose of this study, sites which do not contain moa will be ignored. It is immediately apparent that a similar pattern of distribution is present to that noticed in the natural sites. In many areas various species of birds present in archaeological contexts have become locally extinct but still survive in other more remote areas. This applies particularly to the smaller bush birds. Table I is not intended to be exhaustive and detail of species of kiwi, kakariki or shag are not recorded. Except for Ohawe, where the South Island kiwi occurs, all other occurrences refer to the appropriate geographical forms. It is clear from the natural swamp and cave deposits that the ecological situation of the moa was as part of the forest or forest fringe community. In the archaeological deposits where sufficient detail has been recorded, a similar relationship is evident in that bones of moa and bush birds are found together. Most of the sites in which moa and other extinct birds are common date between A.D. 1000 and A.D. 1350; after this, moa became scarce when the climate was deteriorating and probably becoming drier if not colder. The present distribution of the forest within the 60in rainfall belt would suggest a shift in the rainfall. The present south-easterly cyclonic sea-winds which bring rain to the forested areas must have been much stronger in the past. This in turn suggests that there has been a general change in the atmospheric circulation over New Zealand (Cranwell and Van Post, 1936: 330). The drier climate ensuring after the change was almost certainly the basic cause for the withdrawal of the forest in the eastern South Island and lowland areas of the North Island (Wardle, 1963b: 313).

It is unlikely that the vegetation change was sudden as areas of established forest, by creating their own internal climate, could have persisted long after general conditions became unfavourable. Along the North Otago coast, for instance, moa and bush birds were still being hunted in the fifteenth century, while in South Otago activity was concentrated in the Catlins, an area of bush cover which still survives and Otago Peninsula which still carried large bush areas until 1930. In sites dating from this changeover period, moa are no longer present in sufficient numbers to be a viable source of food. The economy becomes increasingly dependent on sea shore resources. If the economy of the earlier period is labelled " forest hunting " then the economy of the later period is " restricted forest-hunting " leading to the next economic change of " shore-fishing ".

In the North Island, kumara agriculture appears to have become important economically in the fourteenth and fifteenth centuries enabling a smooth transition between the earlier hunting economy and the later periods. In the north, man was able to control his dependence on natural resources; in the south, he was at the mercy of the changing ecology. In either case, far-reaching adaptation to a new ecological situation entailed the evolution of new techniques and tools quite apart from the normal changes taking place in an evolving culture. The passage quoted from Fleming at the beginning of this paper could be rephrased as: The most outstanding event in the recent period of New Zealand was reduction of the forest in the fourteenth century which had profound effects on the vegetation, fauna and the life of prehistoric man.

Table I

Birds in Archaeological Sites

Site	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Moa																		
D. nov. zealandiae		x																x
struthoides		x		x														x
giganteus		x		x	x													
torosus																		
robustus										x								
maximus	x					(x)	(x)			(x)								
gazella				x														
P. elephantopus	x		x			(x)	x	x										
mappini		x		x	x													x
septrionalis		x		x														
oweni																		
Eu. gravis	x		x			x	x	x		x	x	x	x	x	x		x	
geranoides		x		(x)	x													
exilis					x													x
tane		x																
curtus		x			x													
n.sp	x					x												
Em. crassus	x		x			x	(x)	x	x			x						
huttoni	x							x										
A. didiformis	x	x					x		x				x			x		
parvus																		
M. didinus	x		(x)								x							
benhami																		
Extinct Birds																		
Ex. crow	x	x		x			x	x		x				x				
,, takahe	x	x		x											x			
,, gt. rail		x	x	x														
,, sm. rail		x		x						x	x			x		x		
,, eagle		x						x										
,, swan								x						x	x			
,, coot				x			x			x								
,, goose								x							x			
,, duck		x																
,, hawk				x			x								x			

1, Pounawea (South Otago); 2, Ohawe (South Taranaki); 3, Waimataitai (North Otago); 4, Kaupokonui (South Taranaki); 5, Te Rangatapu (South Taranaki); 6, Pleasant River (North Otago); 7, Tai Rua (North Otago); 8, Wairau (Marlborough); 9, Heaphy River (Westland); 10, King's Rock (South Otago); 11, Shepherd's Creek (North Otago); 12, Awamoa (North Otago); 13, Tumbledown Bay (South Canterbury); 14, Native Island (Stewart Island); 15, Ototara (North Otago); 16, Tahunanui (Nelson); 17, Dusky Sound (Fiordland); 18, Whiritoa (Coromandel). ()—probable.

Sites are arranged in order of decreasing age from left to right. Insufficient data are available for a more definite sequence.

TABLE I.—Continued

	SITE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
BUSH BIRDS						Incomplete Data												
Pigeon		x		x			x	x	x						x	x	x	
Tui		x		x	x				x			x						
Bellbird		x																
Kaka		x		x	x			x	x	x	x			x			x	x
Kokako		x		x							x		x				x	
Kiwi (all forms)	x	x		x	x			x	x	x								
Saddleback		x									x							
Robin											x							
Huia		x		x														
Thrush		x									x							
Kakapo		x								x							x	
Kakariki (all species)		x	x	x						x	x		x		x			
Bush Hawk											x				x			
Harrier		x													x			
Weka		x		x		x					x			x	x	x	x	
Laughing Owl			x			x					x			x	x			
Morepork															x			
WATERFOWL	Incomplete Data							Incomplete Data		Incomplete Data								
Grey Duck				x			x				x				x			
Paradise Duck		x	x				x				x	x			x			
Blue Duck				x							x							
Teal		x		x										x	x			
Scaup																		
Pukeko															x			
OPEN COUNTRY BIRDS																		
Quail		x									x				x		x	
Pipit											x							
SEASHORE BIRDS																		
Mottled Petrel											x							
Diving Petrel				x										x	x		x	
Fluttering Shearwater														x			x	
Shearwater			x														x	
Mutton Bird													x	x				
White f. Tern											x				x			
Bl. f. Tern											x							
B. b. Gull											x			x				
R. bill Gull			x	x		x							x	x	x			
Albatross						x	x											
Shag (all species)		x	x	x		x	x		x		x	x	x	x	x	x	x	
Mollymawk		x	x			x	x	x	x					x	x		x	x
Bl. Penguin		x		x	x		x		x				x	x			x	
Penguin (other species)									x			x	x	x	x		x	
Prion														x	x		x	

Details of sources are included in the References.

Appendix I

Sites where Moa Only are Recorded

A list of such sites from the South Island, in presumed chronological order, with the species of moa represented is:

Table II

Moa Associated with Man in the South Island, with no Record of Other Birds

EARLY — LATE

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Dinornis sp.					x		x										
Dinornis maximus		x		x				x		x							
robustus		x		x					(x)								
torosus	x	x															x
Pachyornis elephantopus	x	x		x	?	(x)	(x)						x				
Euryapteryx gravis	x	x	x	x	x	x	(x)	x		x	x	x	x	x			
Euryapteryx n.sp.		x			?									x			
Emeus crassus		x		x	(x)	(x)	(x)	x	x	x	x			x	x		
Emeus huttoni	x	x									x						
Anomalopteryx didiformis		x				(x)							x			x	
Megalapteryx didinus		x															

1, Waitaki (North Otago); 2, Papatowai (South Otago); 3, Kaikai Beach (Dunedin); 4, Shag River (North Otago); 5, Pleasant River (North Otago); 6, Rakaia (South Canterbury); 7, Redcliffs Flat (Christchurch); 8, Little Papanui (Dunedin), (Bottom Layer); 9, Seacliff (Otago); 10, Andersons Bay (Dunedin); 11, Marfell Beach (Grassmere); 12, Hawk's Burn (Central Otago); 13, Hawkesbury; 14, False Island (South Otago); 15, Long Beach (Dunedin); 16, Anapai (Nelson); 17, Tautuku.

At Waitaki, Papatowai, Kaikai, Shag River and Pleasant River, moa are plentiful, at Little Papanui, False Island and Andersons Bay, moa are much scarcer. The first four were all occupied prior to the twelfth century, the latter group are post-fourteenth century (Simmons, 1967).

North Islands sites with a similar record are:

Table III

Moa Associated with Man in North Island Sites with no Information on Other Birds.

	1	2	3	4	5	6	7	8	9	10	11
Dinornis giganteus	x	x	x	x		x					
novaseelandiae	x			x							
struthoides	x	x		x	x				x		
Pachyornis mappini	(x)		x					x			
Euryapteryx geranoides	x				x						
exilus		(x)			x		x				
curtus				x	x		x			x	
tane			x								
Anomalopteryx didiformis		?	x					x			
Megalapteryx didinus			x					(x)			x

1, Tairua (Coromandel)*; 2, Sarah's Gully (Coromandel); 3, Makara Heads (Wellington); 4, Opito I (Golson) (Coromandel); 5, Opito II (Parker) (Coromandel); 6, Manukau Heads (Auckland); 7, Mahinapua (Coromandel); 8, Te Ika a Maru (Wellington); 9, Puketitiri (Hawkes Bay); 10, Tokoroa (Central North Island); 11, Akitea (Wellington).

* Note Tairua also contained Ex. crow. *Pachyornis septrionalis,* pigeon, tui, kaka, kokako, kakariki, bush hawk, laughing owl, ducks and eight species of sea bird. See Smart and Green, *Rec. Dom. Mus.,* 1962, Vol. 1 (Ethnology).

APPENDIX II

C14 Dates for Sites Containing Moa

A.D.

	1000	1100	1200	1300	1400	1500	1600	1700	1800	
Kaikai's Beach	—x—									1050±60 (Lockerbie, pers. comm.)
	Layer I			Layer II						
Pounawea	—x—			—x	x—					1140±60 1400±35 1430±55 (Lockerbie, 1959)
		Layer I		Layer II						
Papatowai		—xx—		—x—						1185±30 1195±30 1320±50 (Lockerbie, 1959)
Wairau Bar		—x—	—x—							1100±50 1220±50 (Duff, 1956; Lockerbie, 1959)
Sarah's Gully		—x—		—xx–x—						1140±50 1300±50 1310±50 1360±50 (Grant-Taylor and Rafter, 1963)
Waimataitai			—x—	—x—						1249±47 1324±30 (Trotter pers. comm.)
Mahinapua				—xx–x—						1310±50 1350±50 1300±50 (Grant-Taylor and Rafter, 1963
Tai Rua					—xxx—					1407±32 1447±32 1465±32 (Trotter, pers. comm.)
Ototara					—x—x—	—				1422±32 1483±70 (Trotter, pers. comm.)
False Is.					—x—					1480±60 (Lockerbie, 1959)
Hawksburn						—x—xx—				1500±60 1540±55 1550±55 (Lockerbie, 1959)
Heaphy R.						—x—				1518±70 (Scarlett and Wilkes, 1963)
Tautuku							—x—			1670±80 (Lockerbie, 1959)

In sites with dates for more than one occupation, the majority of the moa bone comes from the bottom, Layer I.

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Note: Archaeological midden bones are held in the centres from which excavation was directed or where material is still being worked up by the excavator. Otago material is held by L. Lockerbie, Otago Museum and Otago University Anthropology Department; Canterbury material by Canterbury Museum; Nelson material by D. Miller; Wellington material by Dominion Museum and Wellington Archaeological Society; Taranaki material by A. G. Buist and Taranaki Museum; Auckland material by the University of Auckland Anthropology Department.

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